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# Assessment of cognitive, behavioral, and affective learning outcomes in massive open online courses: A systematic literature review

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## ABSTRACT

This systematic review on massive open online courses (MOOCs) in higher education examined the research on the assessment of learning outcomes based on 65 peer-reviewed articles published between 2017 and 2019. This study aims to investigate the learning outcomes, related instruments, and assessment characteristics of these instruments in MOOCs. Learning outcomes that were examined in the studies that were reviewed concerned cognitive, behavioral, and affective learning outcomes. Twenty-five types of assessment approaches were employed to examine these outcomes and to identify the assessment characteristics. The results indicate that a consideration of the assessment of learning outcomes at the beginning of course design could support the formulation of explicit assessment goals and, in this way, instruct learners to work toward learning outcomes. A combination of knowledge tests and skill tasks can be used to examine cognitive outcomes in a particular MOOC. Outcome-oriented feedback rubrics are beneficial to support learner essay performance and interpretations of the utilization of rubrics could better guide providers to give peer feedback. A variety of behavioral and affective outcomes reflect multiple aspects of participant learning in MOOCs, which might contribute to better understanding by teachers and the provision of learning support. Furthermore, assessment tasks throughout the course may differ in difficulty and complexity, which could align with different levels of learner motivation. The findings provide a holistic picture of learning outcomes and related assessment instruments in current MOOCs. Curriculum designers and teachers could benefit from this study to consider appropriate learning outcome variables and instruments to apply in their MOOC practices. Future research might investigate the motivation of learners to participate in a MOOC and how this changes during a MOOC. This could help MOOC designers and teachers to align how learners are motivated, what they want to learn, and what they actually do learn.

## 1. Introduction

Massive open online courses (MOOCs) are a form of online learning with a large student population, and, in most cases, offer free courses and open access. The introduction of MOOCs has changed the way in which higher education resources are delivered. Although

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MOOCs were originally oriented towards informal learning, the acceptance of MOOCs as part of formal campus education has been more recently addressed (Hendriks, de Jong, Admiraal, & Reinders, 2020). MOOCs as campus-like courses have been realized in various practices ranging from undergraduate to graduate education (Yuan, Powell, & Olivier, 2014). Learners participate in MOOCs as part of blended learning or fully online learning, as an obligatory or an optional course, as a non-credit or a credit course, and as complementary to or as a substitute for campus-based courses (Dale & Singer, 2019; Dandache, Frenay, Van Nes, & Verschuren, 2017; Littenberg-Tobias & Reich, 2020; Rayyan et al., 2016; Swinnerton, Morris, Hotchkiss, & Pickering, 2017). Learning assessment is one of the essential aspects of MOOCs. A variety of assessment methods naturally emerge to respond to the demand for measuring learning outcomes, with computer-graded tests and peer assessment the commonly adopted methods to recognize and accredit student learning (Admiraal, Huisman, & Pilli, 2015).

Learning assessment in MOOCs has been regarded as a challenge, and both learners and teachers are aware that assessment instruments should be related to the learning goals of a particular MOOC (Yousef, Chatti, Schroeder, & Wosnitza, 2014). Various learning outcomes in MOOCs have been studied, such as knowledge, skills, academic achievement, engagement, motivation, satisfaction and perceptions of learning (Barak, Watted, & Haick, 2016; Deng, Benckendorff, & Gannaway, 2020; E. E. Jung, Kim, Yoon, Park, & Oakley, 2019; I. Jung & Lee, 2020; Q. Li & Baker, 2018; Shapiro et al., 2017). Xiong and Suen (2018) have discussed different formats of assessments, such as discussion forums, Q&A sessions, quizzes, and automated grading of essays. These assessment forms can be used as formative or summative assessments. In addition to automated tests and self-assessment and peer assessment (Admiraal, Huisman, & Pilli, 2015; Huisman, Admiraal, Pilli, van de Ven, & Saab, 2018; Papathoma, Blake, Clow, & Scanlon, 2015), other methods, such as groups of experts, semantic web, portfolio, and learning analytics, are recommended for use as alternative assessments in MOOCs (del Mar Sánchez-Vera & Prendes-Espinosa, 2015). Although there is a debate about various methods that can be used as learning assessments in MOOCs, it lacks a focus on the connection between learning outcomes and assessment instruments in a wide range of disciplines in higher education.

As Sandeen (2013) claimed, assessment is the core consideration at the very beginning of MOOC course design rather than a later add-on. The match between learning goals, learning outcomes, and assessment instruments is important to guarantee learners will realize the course-required achievements (Bralić & Divjak, 2018; Ewais, Awad, & Hadia, 2020). Assessment of learning outcomes is key to measuring the actual achievements of the students, which is also critical for examining the effectiveness of instructional practices and student learning (Alexandron, Wiltout, Berg, & Ruipérez-Valiente, 2020; Clark, 2002). The current review aims to obtain an overview of learning outcomes and related instruments in MOOCs in order to have a holistic picture of learning outcomes and assessment instruments in different disciplinary fields in higher education MOOCs.

## 2. Learning assessment in MOOCs

Learning assessment in MOOCs has been examined in previous review studies. Ebben and Murphy (2014) reviewed the nascent MOOC scholarship based on 25 peer-reviewed articles published from 2009 to 2013. They distinguished two main categories of MOOCs based on their pedagogical underpinning. The Connectivist MOOCs (cMOOCs) are driven by the learning theory of Connectivism: openness, diversity, autonomy, and connected people within a network of diverse technologies who can share and create knowledge (Bell, 2011; Downes, 2008). The pedagogical design of xMOOCs is similar to on-campus teacher-centered lectures delivered on the platforms. This period witnessed a change in research themes in MOOCs from studying engagement and creativity in early cMOOCs (2009–2012) to investigating the learning analytics and assessment in xMOOCs (2012–2013). Learning assessment of MOOCs paid more attention to accreditation and grant to the credit but focused less on assessment methodology itself. Several colleges and universities, like the University of Maryland and the University of Helsinki, began to grant the completion of a MOOC for credits. Moreover, automated assessment software, like Automated Essay Scoring, was applied in scoring writing assignments, but it was not valid to assess complicated essays.

Sa'don, Alias, and Ohshima (2014) employed data mining to extract the nascent research trend on MOOCs based on 164 papers published from January 2008 to July 2014. This review revealed that assessment and accreditation were included in a list of the most popular research topics. Assessment was also a focus of the MOOC research that was addressed in a review of 146 empirical studies published between October 2014 and November 2016 (Zhu, Sari, & Lee, 2018). This review indicated that future research might more actively target the assessment practices of instructional designers and course instructors of MOOCs. Moreover, Pilli and Admiraal (2017) formulated suggestions for course design based on a review of 56 peer-reviewed studies related to learning outcomes in MOOCs published on or before 2015. These authors adopted the Biggs' 3 P model to examine factors (e.g., student characteristics, course features, and learning activities) which influence student learning outcomes (e.g., engagement, achievement) based on the extraction of previous scientific literature. They suggested that rubrics or other forms of guidance should be combined into peer and self-assessment and that individual student characteristic should be considered in assessment design. In that same year, Vera, Calatayud, and Espinosa (2017) reviewed 38 peer-reviewed studies published between 2012 and 2016 and listed the assessment types applied in MOOCs. Their findings revealed that tests and peer evaluation were common forms of assessment. In most cases, these two assessment approaches were combined to assess learner outcomes. Additionally, the review by Deng, Benckendorff, and Gannaway (2019) analyzed 102 MOOC studies published from 2014 to 2016 that were related to teaching and learning. The findings showed that the complexity of assessment methods is limited and that the learning outcomes lack diversity.

The above reviews synthesized the MOOC studies from 2009 to 2016, presenting a picture of scholarly attention on learning assessment in MOOCs. However, the existing reviews do not yet provide an in-depth insight into the learning outcomes and instruments in MOOCs. These reviews fail to reveal a comprehensive image of a variety of learning outcomes and the instruments themselves in the discipline fields covered in MOOCs. The present study takes account of the categories of learning outcomes and

related instruments, and the assessment characteristics of these instruments, providing an exhaustive analysis of the assessment of learning outcomes in recent MOOC studies. The scientific knowledge base of the assessment of learning outcomes in MOOCs is reviewed by posing three research questions as follows:

- (1) What learning outcomes are assessed in MOOCs?
- (2) What instruments are employed to measure these learning outcomes?
- (3) What assessment characteristics do these instruments have?

### 3. Methods

The methodology utilized in this study is the systematic literature review. The principles of both the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement and the PRISMA explanation and elaboration were employed as the guidelines to conduct and report this review work (Liberati et al., 2009; Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009). The eligibility criteria, information sources, search strategy, study records, data items, and data synthesis recommended in the methods part of the PRISMA-P checklist are described in the following sub-sections.

#### 3.1. Search

The literature search was executed in all electronic databases available in the library of a research university in the Netherlands. This study aims to explore the assessment of learning outcomes in higher education MOOCs. Therefore, the search terms comprise the variants of the term MOOC and synonyms for the terms assessment, learning outcome, and higher education. Since the most identifiable features of MOOCs are massiveness and openness, we did not use other emerging types of MOOCs as the search terms, such as SPOCs, gMOOC, BOOCs, and pMOOC, which are included in the taxonomy of MOOCs by Pilli and Admiraal (2016). The search criteria were used as follows. Search in the title: (MOOC OR massive open online course OR xMOOC or cMOOC). Search in any field: AND (assessment OR evaluation OR learning outcome OR performance OR achievement OR gain) AND (higher education OR college OR university). The last search was performed on July 29, 2019. Articles were included based on the following criteria: (a) peer-reviewed journal articles; (b) written in English; (c) records with full access; (d) available in full text; and (e) published between 2017 and 2019. The period between 2017 and 2019 was chosen due to the previous work of Chauhan (2014), Pilli and Admiraal (2017), and Vera et al. (2017). In total, the search yielded 248 articles, but only 230 articles were available in full-text from the 12 electronic databases (see Table 1).

#### 3.2. Selection

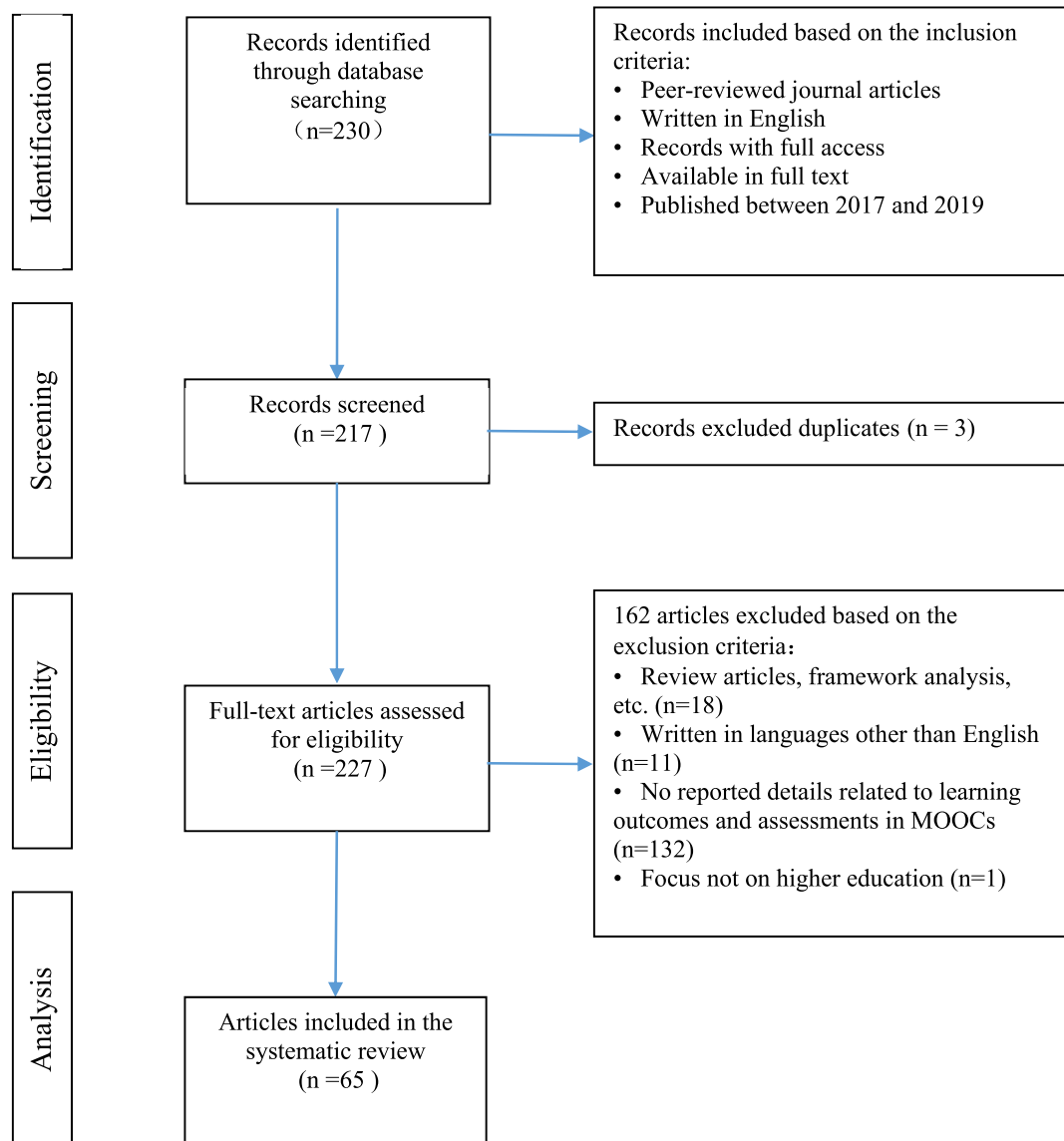
There were a total of 230 articles available in full-text that were downloaded for further manual selection. For each article, the title, abstract, and full text were reviewed by adopting the exclusion criteria to determine the final samples included in the systematic review (see Table 2). Fig. 1 depicts the process of the literature selection, namely identification, screening, eligibility, and analysis, as well as the number of article changes after each stage in the process. By checking the titles, abstracts, and full texts, fifteen articles were removed due to the reasons of duplicates, written in languages other than English, and focus not on higher education; thus, 215 articles remained for further selection. Eighteen articles, including reviews and framework analysis, were filtered out because they did not provide the first-hand data relevant to the assessment of learning outcomes in MOOCs. After further reading of 197 articles, 132 articles were excluded because they did not report details related to learning outcomes and assessments in MOOCs. Ten percent of 230 articles were rated by a co-author and there was a 100% match in the inclusion and exclusion of articles by both raters. Ultimately, the manual selection resulted in 65 eligible articles for the systematic review.

**Table 1**  
Databases collection.

| Name of databases                                    | Number of articles found in the databases |
|------------------------------------------------------|-------------------------------------------|
| ScienceDirect (Elsevier)                             | 50                                        |
| ProQuest                                             | 49                                        |
| Educational Resources Information Center (ERIC)      | 31                                        |
| SpringerLink                                         | 28                                        |
| Web of Science                                       | 20                                        |
| Google Scholar                                       | 18                                        |
| Taylor & Francis Online                              | 16                                        |
| SAGE Journals                                        | 8                                         |
| Wiley Online Library                                 | 5                                         |
| JSTOR (Journal STORage)                              | 3                                         |
| Scholarly and Academic Information Navigator (CiNii) | 1                                         |
| PubMed                                               | 1                                         |
| <b>Total</b>                                         | <b>230</b>                                |

**Table 2**  
Number of excluded articles based on the exclusion criteria.

| Exclusion criteria                                                        | Number of articles excluded based on information in |           |
|---------------------------------------------------------------------------|-----------------------------------------------------|-----------|
|                                                                           | Title/abstract                                      | Full text |
| Review articles, framework analysis                                       | 16                                                  | 2         |
| Written in languages other than English                                   | 11                                                  |           |
| No reported details related to learning outcomes and assessments in MOOCs | 107                                                 | 25        |
| Focus not on higher education                                             | 1                                                   |           |
| Duplicates                                                                | 3                                                   |           |



**Fig. 1.** Literature selection process.

### 3.3. Data analysis

The details related to learning outcomes and assessment instruments are depicted in a matrix. Based on the findings of the selected articles, the learning outcomes were categorized by adopting the taxonomy of Bloom and Krathwohl as cognitive outcomes (e.g., knowledge and skills), behavioral outcomes (e.g., actual behaviors that occurred), and affective outcomes (e.g., value, attitudes,

motivation; ; Bloom, Englehart, Furst, Hill, & Krathwohl, 1956; Krathwohl, Bloom, & Masia, 1964). As subcategories per main outcome category, we used the categories employed by Post, Guo, Saab, and Admiraal (2019) in their review study to specify learning outcomes. Table 3 displays the learning outcomes and instruments included in each study reviewed. In order to group the assessment methods into types of assessment that were used to measure the learning outcomes (i.e., quiz, assignment, survey, user data), we applied the analysis method of Day, van Blankenstein, Westenberg, and Admiraal (2018)). Each article has been coded by (a) assessment type, (b) author/date, (c) country/region, (d) discipline, (e) purpose, (f) assessor, (g) frequency, (h) feedback, (i) mandatory (learners must take the assessments), (j) scoring (contribution to the percentage of the final grades), and (k) reward (to obtain credits/certificate).

## 4. Results

In Table 3, we have included an overview of the articles selected with respect to the learning outcomes they address and the instruments they use. In Tables 4, 5, and 6, we have included the assessment characteristics each article address with respect to cognitive, behavioral, and affective learning outcomes, respectively. These tables are included in the appendix.

### 4.1. Learning outcomes assessed in MOOCs

#### 4.1.1. Cognitive outcomes

Cognitive outcomes relate to the acquisition of knowledge and information and intellectual skills (Bloom, 1956).

**4.1.1.1. Knowledge.** In thirty-two studies, learners' conceptual knowledge and academic achievement were measured as the outcomes of MOOCs. *Conceptual knowledge* refers to knowledge and information that learners have understood and obtained from the subject matter (Bloom, 1956). For example, there were assessments of foundational knowledge in psychology, statistical methods, and computer programming (Najafi, Rolheiser, Håklev, & Harrison, 2017); knowledge concerning the new computing technologies and business process integration (Qiu & Xu, 2018); and content knowledge relevant to astronomy (Formanek, Wenger, Buxner, Impey, & Sonam, 2017) and dementia (Eccleston et al., 2019). Learners' academic achievement in MOOCs was measured in courses such as Biology (Kahan, Soffer, & Nachmias, 2017); Algebra and Pre-Calculus (Q. Li & Baker, 2018); and Classical Sociological Theory (van de Oudeweetering & Agirdag, 2018).

**4.1.1.2. Intellectual skills.** Eight studies reported intellectual skills that learners acquired from MOOCs. *Intellectual skills* concerned a set of domain-specific and generic abilities involved in the thinking processes, such as reasoning, comprehension, thinking abilities, problem-solving, and decision-making skills (Shavelson & Huang, 2003). In the reviewed studies, learners' professional capabilities and broad abilities were assessed. For example, a study by Harvey, Glinsky, Muldoon, and Chhabra (2017) assessed learner clinical reasoning skills in courses about the physiotherapy management of spinal cord injuries. In a study by Najafi et al. (2017), computational thinking in a programming course and critical thinking in a psychological course were identified as learning outcomes of course participants. We see that Meek, Blakemore, and Marks (2017) examined learner writing proficiency of written summaries in a MOOC of biomedical science. Participants in this course showed different levels of proficient outcomes (pass, grades A–C; fail, grades D and E) in written summary exercises. Similarly, in a study by Comer (2017), the MOOC entitled English Composition measured learner writing-related skills by four writing projects. Moreover, broad abilities concerned self-regulated learning were measured in the cases of Onah and Sinclair (2017), referring to goal settings, task strategies, time management, environment structuring, help seeking, and self-evaluation.

#### 4.1.2. Behavioral outcomes

Behavioral outcomes indicate to what extent learners engage in learning based on their behavior in learning activities (e.g., watching video lectures, contributing to discussion forums, and completing assessments) which show positive association with course achievement and completion (Kahan et al., 2017). In terms of behavioral outcomes in the review studies, engagement in learning activities and course completion was examined to illustrate the observable behavior of learners in learning.

**4.1.2.1. Engagement.** Thirty-nine studies measured learners' course engagement (i.e., engagement in course content, course assessment, discussion forums) during MOOC learning (Balint, Teodorescu, Colvin, Choi, & Pritchard, 2017; F. Bonafini, 2017; Chang, Lin, & Chen, 2019; Conijn, Van Den Beemt, & Cuijpers, 2018; Duan, Xie, Hawk, Yu, & Wang, 2019; Jia et al., 2019; Y. Jung & Lee, 2018; Khalil & Ebner, 2017; Lan, Hou, Qi, & Mattheos, 2019; Luo, Zhou, Li, & Xiao, 2018; Patterson, 2018; Torres & Beier, 2018; Wong, Khalil, Baars, de Koning, & Paas, 2019; Yang & Su, 2017). For example, Kahan et al. (2017) investigated the number of video lectures viewed/downloaded, video questions answered, exams/quizzes submitted, thread views/opened, and posts/comments written in the discussion forums, which were used to determine the participant's engagement. Based on these, the authors identified seven types of participant behavior, namely tasters, downloaders, disengagers, offline engagers, online engagers, moderately social engagers, and social engagers. Similarly, Almeda et al. (2018), F. Bonafini, Chae, Park, and Jablokow (2017), and Chiu and Hew (2018) focused on the number of posts/replies/comments and the duration of interactions in the discussion forums. In a study by Kizilcec, Pérez-Sanagustín, and Maldonado (2017), learner interaction with course materials and the time-cost per session activity were assessed, such as lecture begin/complete/revisit and assessment attempt/pass/revisit. Finally, Kovanović et al. (2019) explored seven aspects of students' course engagement: course access, completed assignments, video lectures watched, course navigation, discussion

access, discussion contribution, and discussion reputation.

**4.1.2.2. Course completion.** The outcomes related to course completion were reported in sixteen studies, and earning the course certificate was addressed in fourteen studies (Khalil & Ebner, 2017; Lan et al., 2019; Lee, 2019; Loizzo, Ertmer, Watson, & Watson, 2017; Singh & Mørch, 2018; Torres & Beier, 2018; L. Wang, Hu, & Zhou, 2018). Since the requirements of course completion and course certificate differ in each MOOC, the differentiated degrees of completion could lead learners to receive different types of certificates in that course. Bonafini et al. (2017) reported that one course via the Coursera platform offered two options for a certificate of completion. In this course, the submission of all six weekly tasks is mandatory to obtain a Statement of Accomplishment certificate. When learners would like to obtain a Statement of Accomplishment with Distinction certificate, they also have to submit twelve additional peer reviews. Some studies, such as Najafi, Rolheiser, Harrison, and Heikoop (2018), Jia et al. (2019), Sunar, Abbasi, Davis, White, and Aljohani (2018), and Patterson (2018), also reported the data on course completion and course certificates.

#### 4.1.3. Affective outcomes

Affective outcomes refer to learners' perceptions of their learning in MOOCs. To identify the aspects of affective learning gains in MOOCs, learners' course satisfaction (positive evaluation of courses), perceptions of learning experiences (learners' perceived appreciation in course learning), and benefits (learners' perceived learning improvement) have been examined (Post, Guo, Saab, & Admiraal, 2019).

**4.1.3.1. Course satisfaction.** Satisfaction was measured in seven studies and revealed participants' positive evaluations of the MOOCs (Khalil & Ebner, 2017; K. Li & Moore, 2018; Valdivia Vázquez et al., 2018). For example, de Lima and Zorrilla (2017) measured learners' satisfaction concerning the realization of the learning goals. The results showed that learners expressed high satisfaction with peer interaction, such as support and comments from peers and resource sharing by other participants. K. Li (2019) and Rabin, Kalman, and Kalz (2019) assessed learners' overall satisfaction with the courses. A study by Watson, Watson, Yu, Alamri, and Mueller (2017) investigated the satisfaction of MOOC learners with more specific aspects of the course. Course participants reported their satisfaction with course learning, learning activities, and assignments. This study carried out comparisons among different learner groups with respect to their course satisfaction. The comparative analysis indicated that males reported significantly lower course satisfaction than females, and learners who tended to prefer instructor-led activities had significantly lower satisfaction than learners who tended to prefer exploratory learning activities.

**4.1.3.2. Perceptions of MOOCs experience.** Nineteen studies investigated learners' experiences of learning in MOOCs. Several studies explored emotional feelings of course participants in MOOCs. For example, Buhr, Daniels, and Goegean (2019) reported learners who were bored with the course or enjoyed it, and Loizzo et al. (2017) investigated participants' enjoyment gained within a MOOC. In a study by L. Wang, Hu and Zhou (2018), eight types of learners' emotional tendencies were presented, namely happy, sad, angry, disappointed, surprised, proud, in love, and scared. Some studies investigated participants' perceptions of course learning (e.g., E. Jung et al., 2019; K. Li & Moore, 2018; Meek et al., 2017). For example, both Poquet et al. (2018) and Kovanović et al. (2019) employed the Community of Inquiry (CoI) model to focus on issues related to the social presence of learners (i.e., group cohesion, open communication, and affective expression) in the MOOC environment. Poquet et al. (2018) evaluated the social presence of the different learner groups (i.e., regular posters, occasional posters, and non-posters) in the discussion forums. Kovanović et al. (2019) examined the social presence of three student clusters in terms of course engagement and discussion activity (i.e., limited users, selective users, broad users).

In some studies, learners reported their perceptions of course design, course content, teaching presence, ease of use and usefulness of the course, course usability, network complementarity/size, ease or difficulty of behavioral control, and user preference (e.g., E. Jung et al., 2019; Y. Jung & Lee, 2018; Kovanović et al., 2019; B. Li, Wang, & Tan, 2018; Rabin et al., 2019; Singh & Mørch, 2018; Yang & Su, 2017). Moreover, course participants expressed challenges and barriers with which they were confronted in MOOCs. According to the studies of Shapiro et al. (2017) and Watson et al. (2017), learners faced obstacles concerned with the quite substantial course workload, lack of deep conversation in discussion forums, inadequate prior knowledge of the topics, previous terrible experience with the subjects, and not enough time for learning. Meanwhile, some learners pointed out that the course content was not explained explicitly and deeply enough (Singh & Mørch, 2018; Swinnerton et al., 2017).

**4.1.3.3. Perceptions of MOOCs benefits.** Learning benefits reported by learners were addressed in twenty-five studies. Some studies investigated course participants' motivations (e.g., Loizzo et al., 2017; Valdivia Vázquez et al., 2018) and self-efficacy in MOOCs (e.g., Y. Jung & Lee, 2018). For example, Shapiro et al. (2017) found diverse learner motivations to attend a MOOC, such as knowledge augmentation, improvement of work abilities, development of a future career, and personal interests. DeBoer, Haney, Atiq, Smith, and Cox (2019) conducted a randomized control trial to examine students' self-efficacy in a MOOC about neuroscience topics. At the end of this MOOC, the treatment group of students had a significant growth in self-efficacy in the post-test compared with the results of the pre-test, and the growth of self-efficacy was larger than students in the control group. Both Watson et al. (2017) and Hudson et al. (2019) investigated learners' perceptions of attitudinal learning (i.e., affective, behavioral, and cognitive learning) in MOOCs. Furthermore, several studies have measured other perceived benefits of MOOCs, such as general learning effectiveness (E. Jung et al., 2019; Swinnerton et al., 2017), knowledge sharing and increasing (Singh & Mørch, 2018; Stich & Reeves, 2017), study skills improvement (Rodriguez & Armellini, 2017), sense of progress (E. Jung et al., 2019), confidence (F. Bonafini, 2017; K. Li & Moore,

2018), and user persistence (B. Li et al., 2018; Najafi et al., 2018).

## 4.2. Instrument types and characteristics

### 4.2.1. Assessment instruments of cognitive outcomes

In Table 4, a total of twenty types of assessment instruments were adopted to measure cognitive outcomes. All these measurements refer to a knowledge test, of which quizzes, assignments, tests, exams, and exercises were the most common (e.g., Chiu & Hew, 2018; Moreno-Marcos, Muñoz-Merino, Alario-Hoyos, Estévez-Ayres, & Delgado Kloos, 2018; van den Beemt et al., 2018; Watson et al., 2017). Only eleven types were employed to assess intellectual skills of learners acquired in MOOCs, namely, assignments, surveys, self-assessments, discussion forums, tests, exercises, user data, essays, labs, and writing projects (e.g., Comer, 2017; Krasny et al., 2018). In the discipline column of Table 4, we see that quizzes, exams, and assignments were widely used types across different disciplines to examine knowledge outcomes mastered by learners in MOOCs. Concerning some specific disciplines, such as Computer Science, Social Science, and Humanities, the instruments that were used focused more on skills and competencies. For example, critical thinking and argumentation were measured with essays in psychological courses and computational thinking was assessed with programming exercises in programming courses (Najafi et al., 2017).

In Table 4, we show that the assessment approaches can be adopted for formative or summative assessment purposes. Several studies revealed that summative measurements, like mid-term exams and final exams, aimed to examine learners' academic achievement (DeBoer et al., 2019; Lee, 2019; Patterson, 2018). Najafi et al. (2017) reported that formative assessment approaches with non-graded in-video quizzes and exercises contributed to learners mastering course content in a MOOC about computer programming.

In the assessor column of Table 4, cognitive outcomes were assessed by the computer, learner-self, peer, instructor, researcher, or else who performed the assessment was not reported. In some cases, the computer automatically graded the submissions (e.g., tests, quizzes, assignments, exams, checkpoints, and exercises) and learners could receive automatic grades (Khalil & Ebner, 2017; Lee, 2018). Researchers employed other measurements, such as learners' self-reports, questions answered in interviews, and learning tracked by user data, to investigate how well learners performed in the course learning. For example, in some studies, learners reported that they gained some benefits in MOOCs, such as the development of self-regulated learning skills, pedagogical skills, organizational skills, leadership in the community, programming ability, and comprehension ability (Krasny et al., 2018; Onah & Sinclair, 2017; G. Sun & Bin, 2018; Watson et al., 2017). In the cases of peer review, peers and instructors graded assignments and essays by rubrics and gave feedback that guided learners to make revisions to coursework (Comer, 2017; Formanek et al., 2017).

The amount of assessments faced by learners was quite different across studies. The frequency column in Table 4 shows these discrepancies. The number of assessments is flexible and generally depends on the exact duration of courses. The majority of studies described that the number of assessments embedded in one MOOC ranges from one to ten, like quizzes, exams, tests, exercises, labs, and assignments. Patterson (2018) reported the highest number of assessments in one MOOC: learners had to participate in 53 short quizzes. In contrast, learners in a neuroscience MOOC only had to participate in one graded final exam at the end of the semester (DeBoer et al., 2019). Additionally, the assessments also occurred weekly or bi-weekly, such as weekly quizzes and an optional fortnightly advanced problem set in a MOOC about chemistry (K. Li & Moore, 2018).

Concerning feedback, nine studies reported instruments, such as essays, writing assignments, and writing projects, which provide some types of feedback to course participants. Rubrics are used in some measurements to guide assessors to give feedback on learners' coursework. For example, research by Formanek et al. (2017) focused on how peer assessment contributed to learning and motivation in a MOOC about astronomy. In this study, peers gave feedback by employing a global 0–4 point rubric scale in the first peer-reviewed writing assignment which aimed to evaluate whether learners correctly and concisely answered the questions. In the second peer-reviewed writing assignment, a more exhaustive rubric was applied as a guideline for learners' self-assessment and peer-assessment. Comer (2017) conducted a qualitative study to investigate learners' learning outcomes grounded on peer feedback in an English composition course. The elaborate rubrics demonstrated learning outcome items in writing projects. These rubrics guided learners to provide feedback in two stages: (1) drafting and formative feedback, and (2) revision and peer evaluation. Learners were encouraged to provide specific feedback that could support peers to work toward the course learning outcomes. In addition, web-based tests, a kind of complicated automatic-grading form, provided alternative answers as feedback to learners (Najafi et al., 2017).

As to the columns of mandatory, scoring, and reward in Table 4, in most MOOCs learners were required to participate in course assessments to gain a final course grade and to obtain credits and certificates (e.g., Comer, 2017; Kahan et al., 2017; Lee, 2019). The majority of studies described the proportions of graded assessments in relation to final grades as ranging from 8% to 100% (e.g., quizzes, assignments, exams, discussion forums, homework, essays, and writing projects). Once learners reached the passing requirements, they would receive the certificate or credits. As described in the studies reviewed, the courses differ in the reward standards. For example, learners had to receive a score of at least 60% as a final grade to obtain a completion certificate and a score of at least 90% as a final grade to acquire a distinction certificate (Patterson, 2018). In a MOOC on biology, learners had to score at least 78% as a course grade to receive course credits (Kahan et al., 2017). Yet in a course about computer science, learners had to score at least 75% as a grade in every single trial and complete additional practical work in order to receive credits (Khalil & Ebner, 2017).

### 4.2.2. Assessment instruments of behavioral outcomes

In Table 5, five types of measurements are shown that assess behavioral outcomes, namely user data, surveys, interviews, observations, and group embedded figure tests, with the two most frequently used approaches of user data and surveys (e.g., de Lima & Zorrilla, 2017; Khalil & Ebner, 2017; Singh & Mørch, 2018; Z. Wang, Anderson, & Chen, 2018). The assessors of these instruments were researcher, learner, and computer. Furthermore, no information about several assessment characteristics, including frequency,

purpose, feedback, mandatory, scoring, and reward, was reported.

User data recorded the trajectory of learners' engagement and course completion during the learning process (e.g., Q. Li & Baker, 2018; Rabin et al., 2019; Rizvi, Rienties, Rogaten, & Kizilcec, 2019; Williams, Stafford, Corliss, & Reilly, 2018; Xing, 2019). Learning analytics techniques and educational data mining were implemented to extract user data to gain insight into learners' behavioral outcomes in MOOCs. For example, Q. Li and Baker (2018) identified learners' behavior based on user data of quiz submission and video interaction and identified subgroups of study patterns (i.e., disengagers, auditors, quiz-takers, and all-rounders). Sunar et al. (2018) categorized learners' behavior into subgroups by the data of learners' contribution and interaction in the discussion threads. Five social patterns were identified: simple, moderately frequent, frequent, and persistent frequent.

The self-report questionnaires were utilized to reveal learners' online learning processes. For example, Kizilcec et al. (2017) adopted a five-point scale with 23 statements to investigate learners' engagement with self-regulated learning strategies (SRL; e.g., elaboration, strategic planning) to support their MOOC learning and how these strategies drive learners' online behavior. Y. Jung and Lee (2018) modified items from J. Sun and Rueda (2012) and employed five-point Likert scales to investigate participants' engagement in five courses, namely psychology, design, humanities, musicology, and physics. Additionally, other tools, such as interviews (Krasny et al., 2018), observations (Singh & Mørch, 2018), and group embedded figure tests (Chang et al., 2019), were used to examine behavioral outcomes of attendees in MOOCs.

#### 4.2.3. Assessment instruments of affective outcomes

In Table 6, five types of assessment approaches were utilized to assess the perceptions of learners' various affective outcomes of MOOC learning. Among these approaches, surveys and interviews were the two most commonly used, followed by observations, self-assessment, and user data. In the columns of discipline, frequency, and assessor, we see that these instruments were widely used across disciplines. DeBoer et al. (2019) and Kormos and Nijakowska (2017) conducted surveys at pre-course and post-course, and affective outcomes were evaluated by learners themselves and researchers. No information is available on the categories of characteristics of feedback, mandatory, scoring, and reward.

Likert scales were commonly applied in self-report questionnaires to reflect learners' perceptions of affective learning gains, such as learning experience, perceived learning benefits, and course satisfaction (e.g., DeBoer et al., 2019; Y. Jung & Lee, 2018; K. Li, 2019; Rabin et al., 2019; Yang & Su, 2017). For example, K. Li (2019) applied five-point agreement Likert scales and seven-point likelihood Likert scales for learners to rate the items on course satisfaction and perceived cognitive and affective learning. Rabin et al. (2019) conducted surveys by utilizing seven-point satisfaction and seven-point agreement Likert scales to mirror learners' course satisfaction, perceived course usability, and intention-fulfillment in a nine-week MOOC. In some studies, interviews disclosed the interviewee's evaluation of their learning in MOOCs (e.g., Hudson et al., 2019; K. Li & Moore, 2018; Watson et al., 2017). For a deeper understanding of group leaders in terms of professional development, leader motivations, and barriers encountered, Krasny et al. (2018) conducted semi-structured interviews with open-ended questions with a small number of students. Other types of measurements, such as observations (Loizzo et al., 2017) and self-assessments (F. Bonafini, 2017), were employed to reveal learners' evaluations on learning experiences and benefits in MOOCs. Additionally, in L. Wang, Hu, & Zhou, 2018, user data was used to identify learners' emotional experiences and emotional states.

## 5. Discussion

In this systematic review, we examined: (1) the learning outcomes that are assessed in MOOCs; (2) the instruments that are employed to assess these learning outcomes; and (3) the assessment characteristics of these instruments. Learning outcomes that were measured belong to a wide range of disciplines, with the main fields including STEM (science, technology, engineering, and mathematics), humanities and social science, and the medical sciences. We found that various types of instruments were employed to assess cognitive outcomes, behavioral outcomes, and affective outcomes, and these instruments had their own characteristics.

### 5.1. Assessment of cognitive outcomes

Learners' *cognitive outcomes* were measured to mirror the *knowledge* and *intellectual skills* obtained and mastered, which were universal outcomes identified in most MOOCs. Twenty types of instruments were utilized to assess these outcomes, such as quizzes, assignments, tests, exams, exercises, and writing projects, with quizzes, assignments, and exams the most frequently used approaches.

In the field of STEM, we found that most of the assessments, such as quizzes, exams, exercises, tests, labs, and homework, are built into the video lectures or follow each course session, with the aim to examine to what extent learners have learned the information that was taught and presented in the subject matter and learning materials. These assessments have different functions that can be used in a formative or summative way. For example, exams are commonly used for a midterm or final summative purpose in the studies reviewed. In another study in a programming course, participants had multiple opportunities to submit exercises so that they could self-diagnose the problematics and control the learning outcomes themselves, which gave the assessment a formative function (Najafi et al., 2017). Generally, graded assessments which examine the required learning outcomes and make up a proportion of the final course grades are mandatory. Since it is easy in STEM courses to provide standardized and explicit answers in the assessments, in most cases the auto-graded selected-response questions and short-answer questions with feedback are quick and efficient for a large number of learners to understand their performance. The elaborate interpretations and feedback of the questions related to the core subject matter could enhance learners' understanding. Moreover, examinations that focus more on the disciplinary-related and practice-related skills are also part of assessing learning outcomes. For example, in (Najafi et al., 2017), the combination of assessment

approaches in a Stats MOOC addressed multiple cognitive outcomes: quizzes examined the content knowledge gains, while complex assignments measured the skills of knowledge application and statistical analysis.

In the MOOCs about humanities and social science, instruments like essays, writing assignments, and writing projects were utilized to evaluate learners' knowledge, critical competencies, and argumentation abilities. We found that peer review and peer feedback with the help of rubrics were features of essay-type assessments. Peer feedback rubrics measured writing-related outcomes and guided the assessors to check and comment on the components of the writing. The rubrics with structured criteria constructed the road map for both feedback providers and learners towards learning outcomes. For example, in a study by [Comer \(2017\)](#), peer feedback rubrics identified stages of outcome progress which learners used for self-reflection and self-critique, thereby providing support to improve their writing. Learners indicated that they gained significant benefits from peer review of writing, such as writing proficiency and task understanding. However, one point must be given attention, namely that students' ability to peer review generally affects learners' performance on essay assignments ([Huisman, Admiraal, Pilli, van de Ven, & Saab, 2018](#)). Explicit interpretations about the utilization of feedback forms could perhaps better guide providers and improve the quality of peer feedback ([Comer, 2017](#)). In sum, in MOOCs of humanities and social science, outcome-oriented feedback rubrics can play a scaffolding role in supporting and stimulating learners' performance in essay-type assignments.

Concerning the MOOCs in medical science, examinations, such as exams, tests, and assessments, addressed learners' cognitive learning gains and the graded examinations contributed to a proportion of the final grades. The topic tests and in-class tests that were used in [Jia et al. \(2019\)](#) realized formative and summative purposes with both graded and non-graded assessments. The studies reviewed indicated that medical-related courses have components which concern the application of professional knowledge and intellectual skills, with practice-oriented assessments bridging medical theory and authentic practices. Participants learned from case scenarios or patient problems and their performance in the practice cases was assessed. For example, case discussions and virtual patient cases can both support and measure learners' comprehensive knowledge and competencies, such as theoretical and fundamental knowledge, clinic procedures, clinic reasoning, and decision making ([Jia et al., 2019](#); [Lan et al., 2019](#)). Teachers led the group discussions to address the questions ([Jia et al., 2019](#)), peer and self-assessment measured learners' performance on case problems, and peer solutions contributed to self-reflection ([Lan et al., 2019](#)). Furthermore, it is necessary to facilitate learners in higher-level cognitive processing when participating in MOOC forums, which could stimulate learners to provide more constructive feedback to peers to improve outcomes. This is corroborated by a recent study of [Chiu and Hew \(2018\)](#) which revealed that commenting (higher cognitive processing) on posts in discussion forums has a significant correlation with participants' academic performance. Overall, in medical-related courses, discussion forums could support learners to gain better learning outcomes from medical theory and authentic cases. Instructors, who fulfill the role of leader and facilitator, are essential to engage learners actively in discussion forums.

It could also be doubted whether the same standard measurement is a valid assessment of the learning outcomes of all learners within one MOOC. In the studies reviewed, the same standard measurement was used to assess all learners in one course, which fails to consider the heterogeneity of learners. Since a diverse group of learners participates in MOOCs with various motivations, such as course complement, professional needs, satisfying curiosity, and connecting with people, their learning needs might differ as well ([Zheng, Rosson, Shih, & Carroll, 2015](#)). Examples of different learner groups are active learners who aim to complete and pass the course and lurkers who do not involve themselves in learning or complete any assessment tasks at all ([Alario-Hoyos, Pérez-Sanagustín, Delgado-Kloos, & Muñoz-Organero, 2014](#)). Measurement with the same standard within a course might not satisfy all learners' learning needs. One way could be to apply the assessments in each learner group but differentiated in difficulty and complexity. For example, in a study by [Najafi et al. \(2018\)](#), the higher motivation learner group who were actively engaged in courses achieved significantly better grades than the lower motivation learner group. To take into account the motivation level of these groups, the higher motivation learner group could participate in more difficult and more complex assessment tasks. In contrast, the lower motivation learner group could take the standard assessment tasks or other adaptive assessments. The assessment characteristics of the methods could be helpful to consider appropriate ways to fit learning outcomes. In a word, differentiated learning assessments might align with learners' motivation levels and lead all of them to fulfill learning goals in the end.

## 5.2. Assessment of behavioral and affective outcomes

When we look at the assessment of behavioral and affective outcomes, instruments like user data, surveys, interviews, and observations were utilized as external evaluation tools to explore different aspects of participant learning in MOOCs. There are multiple variables of behavioral and affective outcomes that have been explored and different measurements that have been applied.

With regard to assessments of behavioral outcomes, user data was frequently adopted to disclose various sorts of objective learning behavior and record the trajectory of learners' learning processes and capture the moments of learner activity during MOOC learning. Extracting user data can provide insight into how learners behave while learning, such as the times/duration of watching video lectures, the number of posts/replies/comments in discussion forums, and the completion and submission of assessment tasks. This data could provide curriculum teachers with quantitative information about the course and reveal to what extent learners are engaged in course learning. For example, the number of videos watched and the number of posts are significantly associated with learners' achievement ([F. Bonafini et al., 2017](#)). Moreover, user data can also help scholars to explore further multiple and complex aspects of the learning process. For example, the different pathways of learners' access to learning resources and a variety of behaviors can

identify the self-regulated learning strategies used by learners (Maldonado-Mahauad, Pérez-Sanagustín, Kizilcec, Morales, & Munoz-Gama, 2018), the types of social networks which emerge (de Lima & Zorrilla, 2017), and the problem-solving patterns used by learners (Lee, 2019).

Concerning the assessment of affective outcomes, questionnaires were most frequently employed to survey learners' perceptions of learning in MOOCs. The majority of studies explicitly described the methodology adopted, reported the constructs, reliability and validity of the measurements, and included in detail the items of the scales (e.g., Buhr et al., 2019; DeBoer et al., 2019; Hudson et al., 2019; Kormos & Nijakowska, 2017). Curriculum designers and teachers have access to the complete information and parameters of the survey tools so that they can obtain learners' perceptions in detail from these instruments. However, several studies lacked the presentation of either the rated items or psychometric properties (e.g., Rodriguez & Armellini, 2017; Valdivia Vázquez et al., 2018), which might impede readers in further understanding the results and interpretations of the study. Other instruments like interviews and observations were used for qualitative data collection in the affective domain. Some studies reported methods, such as group discussion, member checking, inter-rater agreement, interviewee review transcripts, which were used to check for validity of the qualitative analysis (e.g., Hudson et al., 2019; Loizzo et al., 2017; Watson et al., 2017; Wu, Kao, Wu, & Wei, 2019). In sum, questionnaires map learners' perceptions by means of quantitative methods, and interviews and observations can mirror qualitative views of learners' learning.

This review also found that the cognitive, behavioral, and affective outcomes were correlated. Some of the studies reviewed gained insight into their correlation. For example, engagement and interaction duration in discussion forums were positively associated with course achievement (Almeda, 2018; F. Bonafini et al., 2017; Chiu & Hew, 2018), high-quality peer interactions in peer-reviewed tasks led to higher performance (Meek et al., 2017), and course completers showed active social interactions (Sunar et al., 2018). The results of Y. Jung and Lee (2018) indicated that learners' engagement was correlated with learning persistence, teaching presence, perceived usefulness, and academic self-efficacy. Watson et al. (2017) revealed that learners who were rewarded with paid certificates had higher perceived affective learning gains than those who received free certificates, and learners who preferred exploratory activities had a higher sense of course satisfaction than learners in instructor-led activities. These studies have proved that learning outcomes are complex and comprise a variety of variables and that positive behavioral and affective gains promote the acquisition of cognitive outcomes. The results of these studies might benefit curriculum designers and teachers so that they can understand and support learners' learning from multiple perspectives based on the correlation among cognitive, behavioral, and affective learning outcomes and then optimize the curriculum and instruction in the future.

## 6. Limitations and future research

The main limitation we would like to address is the possibility of publication bias. Publication bias is a common problem with literature reviews because studies that show positive or significant results tend to be published more often. In our current review study, most of the studies reported the assessment of cognitive outcomes of MOOCs, which might be caused by the fact that most of the positive or significant results are about cognitive outcomes. There might be other studies concerning the assessment of behavioral outcomes and affective outcomes of MOOCs that were not published because these studies did not show significant results. Yet the aim of the current review is descriptive: an exploration of types of learning outcomes and approaches to assess these outcomes. Therefore, this publication bias might not violate the conclusions of our review.

The studies reviewed provide an overview of the assessment of cognitive, behavioral, and affective dimensions of learning outcomes in MOOCs. We hope that this review enables MOOC designers and teachers to have a holistic understanding of diverse learning outcomes and instruments. To better understand how learners achieve particular learning outcomes, investigating the motivation of learners to participate in a MOOC and how this changes during a MOOC could be a direction of future research. This could help MOOC designers and teachers to align how learners are motivated, what they want to learn, and what they actually do learn.

## 7. Concluding remarks

In this review study, learning outcomes were distinguished and various types of assessments in MOOCs were characterized. This review reveals multiple types of assessment instruments and diverse learning outcomes that extend the previous focus on outcomes such as engagement, academic achievement, and attrition (Pilli & Admiraal, 2017) and the findings of the assessment of learning outcomes in the reviews of Vera et al. (2017) and Deng et al. (2019). The review findings could benefit curriculum designers and teachers to consider appropriate learning outcome variables and assessment approaches to serve their assessment needs.

The main outcomes of this review study indicate that:

- (1) By considering the assessment of learning outcomes at the beginning of course design, appropriate measurements could support the formulation of explicit assessment goals and instruct learners to work towards learning outcomes.
- (2) A combination of knowledge tests and skill tasks can be used to examine cognitive outcomes in a particular MOOC. For example, quizzes and exams can be approaches to examine content knowledge, while complex assessment tasks and practical assignments can aim to assess cognitive skills.

- (3) Outcome-oriented feedback rubrics are beneficial to support learner essay performance and interpretations of the utilization of rubrics could better guide providers to give peer feedback.
- (4) A variety of behavioral and affective outcomes reflect multiple aspects of participant learning in MOOCs, which might contribute to better understanding by teachers of the support needed by participants to learn.
- (5) Assessment tasks throughout the course may differ in difficulty and complexity, which could align with different levels of motivation of the learners.

### Credit author statement

Xiaomei Wei: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Writing - review & editing, Visualization, Funding acquisition, Project administration. Nadira Saab: Conceptualization, Methodology, Formal analysis, Writing - review & editing, Supervision, Project administration. Wilfried Admiraal: Conceptualization, Methodology, Formal analysis, Writing - review & editing, Supervision, Project administration.

### Declarations of competing interest

None.

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### Appendix

**Table 3**

An overview of learning outcomes and assessment instruments in the studies reviewed.

| Authors (year)                  | Cognitive outcomes |                                     | Behavioral outcomes |                            | Affective outcomes |                   |
|---------------------------------|--------------------|-------------------------------------|---------------------|----------------------------|--------------------|-------------------|
|                                 | Outcome type       | Instruments                         | Outcome type        | Instruments                | Outcome type       | Instruments       |
| 1. Almeda et al. (2018)         | K                  | Course requirements                 | E                   | User data                  |                    |                   |
| 2. Balint et al. (2017)         |                    |                                     | E                   | User data                  |                    |                   |
| 3. Bonafini (2017)              | K; IS              | Discussion forum                    | E                   | User data                  | PB                 | Self-assessment   |
| 4. Bonafini et al. (2017)       |                    |                                     | E; COM              | User data                  |                    |                   |
| 5. Buhr et al. (2019)           |                    |                                     |                     |                            | PE                 | Survey            |
| 6. Chang et al. (2019)          | K                  | Group embedded figure test          | E                   | Group embedded figure test |                    |                   |
| 7. Chiu and Hew (2018)          | K                  | Quiz, assignment                    | E                   | User data                  |                    |                   |
| 8. Comer (2017)                 | K; IS              | Writing projects                    |                     |                            | PB                 | User data         |
| 9. Conijn et al. (2018)         | K                  | Quiz, exam, assignment              | E                   | User data                  |                    |                   |
| 10. de Lima and Zorrilla (2017) |                    |                                     | E                   | User data                  | SAT                | Survey            |
| 11. DeBoer et al. (2019)        | K                  | Exam                                |                     |                            | PB                 | Survey            |
| 12. Duan et al. (2019)          |                    |                                     | E                   | User data                  |                    |                   |
| 13. Eccleston et al. (2019)     | K                  | Survey                              |                     |                            |                    |                   |
| 14. Emanuel and Lamb (2017)     | K                  | Assessment                          | E; CER              | User data                  |                    |                   |
| 15. Formanek et al. (2017)      | K                  | Quiz, assignment, online activities |                     |                            |                    |                   |
| 16. Harvey et al. (2017)        | K; IS              | Assessment                          | E                   | User data                  |                    |                   |
| 17. Hudson et al. (2019)        |                    |                                     | E                   | Survey                     | PB                 | Survey, interview |
| 18. Jia et al. (2019)           | K                  | Test, exam, discussion forum        | E; COM              | User data                  |                    |                   |
| 19. Jung and Lee (2018)         |                    |                                     | E                   | Survey                     | PB; PE             | Survey            |
| 20. Jung et al. (2019)          |                    |                                     |                     |                            | PB; PE             | Survey            |
| 21. Kahan et al. (2017)         | K                  | Quiz, exam                          | E; CER              | User data                  |                    |                   |
| 22. Khalil and Ebner (2017)     | K                  | Quiz, practical work                | E; COM; CER         | User data                  | SAT                | Survey            |

(continued on next page)

Table 3 (continued)

| Authors (year)                              | Cognitive outcomes |                                                                 | Behavioral outcomes |                     | Affective outcomes |                        |
|---------------------------------------------|--------------------|-----------------------------------------------------------------|---------------------|---------------------|--------------------|------------------------|
|                                             | Outcome type       | Instruments                                                     | Outcome type        | Instruments         | Outcome type       | Instruments            |
| 23. Kizilcec et al. (2017)                  |                    |                                                                 | E; CER              | Survey, user data   |                    |                        |
| 24. Kormos and Nijakowska (2017)            |                    |                                                                 |                     |                     | PB; PE             | Survey                 |
| 25. Kovanović et al. (2019)                 | K; IS              | Homework, labs                                                  | E                   | User data           | PB; PE             | Survey                 |
| 26. Krasny et al. (2018)                    |                    |                                                                 |                     |                     | PB; PE             | Survey, interview      |
| 27. Lan et al. (2019)                       | K                  | Assessment                                                      | E; COM; CER         | User data           |                    |                        |
| 28. Lee (2018)                              | K                  | Checkpoints, homework, quiz, exam                               | E; CER              | User data           |                    |                        |
| 29. Lee (2019)                              | K                  | Checkpoints, homework problems, quiz, exam                      | E; COM; CER         | User data           |                    |                        |
| 30. Li and Baker (2018)                     | K                  | Quiz                                                            | E                   | User data           |                    |                        |
| 31. Li and Moore (2018)                     | K                  | Quiz, exam, problem sets                                        |                     |                     | PB; PE; SAT        | Survey, interview      |
| 32. Li (2019)                               |                    |                                                                 |                     |                     | PB; PE; SAT        | Survey                 |
| 33. Li et al. (2018)                        |                    |                                                                 | COM                 | Survey              | PB; PE             | Survey                 |
| 34. Loizzo et al. (2017)                    |                    |                                                                 | COM; CER            | Interview           | PB; PE             | Interview, observation |
| 35. Luo et al. (2018)                       |                    |                                                                 | E                   | User data           |                    |                        |
| 36. Maldonado-Mahauad et al. (2018)         |                    |                                                                 | E                   | User data           |                    |                        |
| 37. Meek et al. (2017)                      | K; IS              | Assignment                                                      | E                   | Survey              | PB; PE             | Survey                 |
| 38. Moreno-Marcos et al. (2018)             | K                  | Test, assignment                                                |                     |                     |                    |                        |
| 39. Najafi et al. (2017)                    | K; IS              | Essay, quiz, assignment, exercise, exam, test, discussion forum |                     |                     |                    |                        |
| 40. Najafi et al. (2018)                    | K                  | Quiz, assignment, course project                                | COM                 | User data           | PB                 | Survey                 |
| 41. Onah and Sinclair (2017)                | IS                 | Survey                                                          |                     |                     |                    |                        |
| 42. Patterson (2018)                        | K                  | Exam, quiz, assignment                                          | E; COM; CER         | User data           |                    |                        |
| 43. Poquet et al. (2018)                    |                    |                                                                 | E                   | User data           | PE                 | Survey                 |
| 44. Qiu and Xu (2018)                       | K                  | Assignment, exam                                                | CER                 | Survey              |                    |                        |
| 45. Rabin et al. (2019)                     |                    |                                                                 | E; CER              | User data           | PB; PE; SAT        | Survey                 |
| 46. Rizvi et al. (2019)                     |                    |                                                                 | E                   | User data           |                    |                        |
| 47. Rodriguez and Armellini (2017)          |                    |                                                                 |                     |                     | PB                 | Survey                 |
| 48. Shapiro et al. (2017)                   |                    |                                                                 |                     |                     | PB; PE             | Interview              |
| 49. Singh and Mørch (2018)                  | K                  | Quiz, assessment                                                | E; COM              | Survey, observation | PB; PE             | Survey                 |
| 50. Stich and Reeves (2017)                 |                    |                                                                 | COM                 | Survey              | PB; PE             | Survey                 |
| 51. Sun and Bin (2018)                      | IS                 | User data                                                       |                     |                     |                    |                        |
| 52. Sunar et al. (2018)                     |                    |                                                                 | E; COM              | User data           |                    |                        |
| 53. Swinnerton et al. (2017)                |                    |                                                                 | E                   | Survey              | PB; PE             | Survey                 |
| 54. Torres and Beier (2018)                 | K                  | Quiz, discussion forum                                          | E; COM              | User data           |                    |                        |
| 55. van de Oudeweetering and Agirdag (2018) | K                  | Assignment, quiz, exam                                          | COM                 | Survey              |                    |                        |
| 56. van den Beemt et al. (2018)             | K                  | Quiz, assignment                                                | E; CER              | User data           |                    |                        |
| 57. Valdivia Vázquez et al. (2018)          |                    |                                                                 |                     |                     | PB; SAT            | Survey                 |
| 58. Wang, Anderson, and Chen (2018)         |                    |                                                                 | E                   | User data           |                    |                        |
| 59. Wang, Hu, and Zhou (2018)               |                    |                                                                 | E; COM; CER         | User data           | PE                 | User data              |
| 60. Watson et al. (2017)                    | K                  | Assessment, quiz, exam, exercise                                | CER                 | User data           | PB; SAT            | Survey, interview      |
| 61. Williams et al. (2018)                  |                    |                                                                 | E                   | User data           |                    |                        |
| 62. Wong et al. (2019)                      |                    |                                                                 | E                   | User data           |                    |                        |
| 63. Wu et al. (2019)                        |                    |                                                                 |                     |                     | PB                 | Interview              |
| 64. Xing (2019)                             | K                  | Quiz, test                                                      | COM                 | User data           |                    |                        |
| 65. Yang and Su (2017)                      |                    |                                                                 | E                   | Survey              | PB; PE             | Survey                 |

Note: K = knowledge, IS = intellectual skills, E = engagement, COM = course completion, CER = course certificate, PE = perceptions of MOOCs experience, PB = perceptions of MOOCs benefits, SAT = course satisfaction.

**Table 4**

An overview of assessment characteristics of cognitive outcomes in the studies reviewed.

| Assessment type | Authors (year)                              | Country/<br>Region | Discipline                                                   | Cognitive<br>Outcomes | Assessment characteristics |            |                                                                                                                                        |          |           |                                                                                       |                     |
|-----------------|---------------------------------------------|--------------------|--------------------------------------------------------------|-----------------------|----------------------------|------------|----------------------------------------------------------------------------------------------------------------------------------------|----------|-----------|---------------------------------------------------------------------------------------|---------------------|
|                 |                                             |                    |                                                              |                       | Purpose                    | Assessor   | Frequency                                                                                                                              | Feedback | Mandatory | Scoring                                                                               | Reward              |
| Quiz            | 7. Chiu and Hew (2018)                      | China-Hong Kong    | No info                                                      | K                     | No info                    | No info    | 2                                                                                                                                      | No info  | Yes       | No info                                                                               | Certificate         |
|                 | 9. Conijn et al. (2018)                     | The Netherlands    | Computer Science                                             | K                     | No info                    | No info    | 9 graded quizzes; 5 practice quizzes                                                                                                   | No info  | No info   | No info                                                                               | No info             |
|                 | 15. Formanek et al. (2017)                  | USA                | Physical Science & Engineering                               | K                     | No info                    | Computer   | 13                                                                                                                                     | No info  | Yes       | 60% of grade                                                                          | No info             |
|                 | 21. Kahan et al. (2017)                     | Israel             | Biology                                                      | K                     | Formative                  | No info    | 6                                                                                                                                      | No info  | Yes       | 50% of grade                                                                          | Credit, certificate |
|                 | 22. Khalil and Ebner (2017)                 | Austria            | No info                                                      | K                     | Formative                  | Computer   | 10                                                                                                                                     | No       | Yes       | No info                                                                               | Credit, certificate |
|                 | 28. Lee (2018)                              | USA                | Engineering                                                  | K                     | Summative                  | No info    | No info                                                                                                                                | No info  | Yes       | 36% of grade                                                                          | Certificate         |
|                 | 29. Lee (2019)                              | USA                | Engineering                                                  | K                     | Summative                  | Computer   | No info                                                                                                                                | No info  | Yes       | 36% of grade                                                                          | Certificate         |
|                 | 30. Li and Baker (2018)                     | USA                | Mathematics                                                  | K                     | No info                    | No info    | 32 in Algebra and Pre-calculus 2, respectively; 52 in Pre-calculus                                                                     | No info  | Yes       | No info                                                                               | Certificate         |
|                 | 31. Li and Moore (2018)                     | USA                | Chemistry                                                    | K                     | No info                    | No info    | Weekly quizzes                                                                                                                         | No info  | No info   | No info                                                                               | Certificate         |
|                 | 39. Najafi et al. (2017)                    | Canada             | Health, Computer Science, Social Science & Humanities        | K                     | Formative                  | Computer   | 307 and 140 in-video quizzes in 3 hard MOOCs, and 3 soft MOOCs, respectively; 2 quizzes in AboriginalEd; 1 bonus quiz in Mental Health | No info  | Yes       | Not contribute to grade; 40% of grade in AboriginalEd; 10% of grade in Mental Health. | No info             |
|                 | 40. Najafi et al. (2018)                    | Canada             | Computer Science                                             | K                     | No info                    | No info    | ≥2 in Bio1 course; 5 in iOSApp1 and iOSApp2, respectively                                                                              | No info  | Yes       | No info                                                                               | No info             |
|                 | 42. Patterson (2018)                        | USA                | No info                                                      | K                     | No info                    | No info    | 53                                                                                                                                     | No info  |           | 10% of grade                                                                          | Certificate         |
|                 | 49. Singh and Mørch (2018)                  | Norway             | Nature & Environment                                         | K                     | No info                    | No info    | No info                                                                                                                                | No info  | No info   | No info                                                                               | No info             |
|                 | 54. Torres and Beier (2018)                 | USA                | No info                                                      | K                     | No info                    | Instructor | No info                                                                                                                                | No info  | Yes       | 60% of grade                                                                          | Certificate         |
|                 | 55. van de Oudeweetering and Agirdag (2018) | The Netherlands    | Physical Science & Engineering, Social Science, Data Science | K                     | No info                    | No info    | No info                                                                                                                                | No info  | Yes       | No info                                                                               | No info             |
|                 | 56. van den Beemt et al. (2018)             | The Netherlands    | Data Science                                                 | K                     | No info                    | No info    | 6 weekly quizzes; 1 final quiz                                                                                                         | No info  | Yes       | No info                                                                               | Certificate         |

(continued on next page)

Table 4 (continued)

| Assessment type | Authors (year)                                  | Country/<br>Region | Discipline                                                                                                                                                                                                  | Cognitive<br>Outcomes | Assessment characteristics |                  |                                                                                      |          |           |                                                                                    |             |
|-----------------|-------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------|------------------|--------------------------------------------------------------------------------------|----------|-----------|------------------------------------------------------------------------------------|-------------|
|                 |                                                 |                    |                                                                                                                                                                                                             |                       | Purpose                    | Assessor         | Frequency                                                                            | Feedback | Mandatory | Scoring                                                                            | Reward      |
| Assignment      | 60. <a href="#">Watson et al. (2017)</a>        | USA                | Social Science                                                                                                                                                                                              | K                     | Formative                  | No info          | 10                                                                                   | No info  | No info   | No info                                                                            | No info     |
|                 | 64. <a href="#">Xing (2019)</a>                 | China-Taiwan       | Business & Management, Computer Science, Education, Humanities, Mathematics & Statistics, the Medical Science, the Physical Science, the Professional & Applied science, interdisciplinary and other fields | K                     | No info                    | No info          | No info                                                                              | No info  | No info   | No info                                                                            | No info     |
|                 | 7. <a href="#">Chiu and Hew (2018)</a>          | China-Hong Kong    | No info                                                                                                                                                                                                     | K                     | No info                    | Peer             | 4                                                                                    | No info  | Yes       | No info                                                                            | Certificate |
|                 | 9. <a href="#">Conijn et al. (2018)</a>         | The Netherlands    | Computer Science                                                                                                                                                                                            | K                     | No info                    | Peer             | 1 Peer-reviewed assignment                                                           | Yes      | Yes       | No info                                                                            | No info     |
|                 | 15. <a href="#">Formanek et al. (2017)</a>      | USA                | Physical Science & Engineering                                                                                                                                                                              | K                     | Formative                  | Peer, instructor | 3                                                                                    | Rubrics  | Yes       | 20% of grade                                                                       | No info     |
|                 | 37. <a href="#">Meek et al. (2017)</a>          | UK                 | Health & Psychology                                                                                                                                                                                         | K                     | Summative                  | Peer, academics  | 1                                                                                    | Rubrics  | Yes       | No info                                                                            | No info     |
|                 | 38. <a href="#">Moreno-Marcos et al. (2018)</a> | Spain              | Computer Science                                                                                                                                                                                            | K                     | Formative                  | Peer             | 2                                                                                    | Rubrics  | Yes       | 25% of grade                                                                       | No info     |
|                 | 39. <a href="#">Najafi et al. (2017)</a>        | Canada             | Computer Science                                                                                                                                                                                            | IS                    | Formative                  | Peer, computer   | 3 assignments in Programming1; 2 assignments in Programming2 and Stats, respectively | Rubrics  | Yes       | 40% of grade in Programming1; 40% of grade in Programming2; 30% of grade in Stats. | No info     |
|                 | 40. <a href="#">Najafi et al. (2018)</a>        | Canada             | Computer Science                                                                                                                                                                                            | K                     | No info                    | No info          | 1 in Bio1 course                                                                     | No info  | Yes       | No info                                                                            | No info     |
|                 | 42. <a href="#">Patterson (2018)</a>            | USA                | No info                                                                                                                                                                                                     | K                     | No info                    | No info          | 9                                                                                    | No info  | Yes       | 45% of grade                                                                       | Certificate |
|                 | 44. <a href="#">Qiu and Xu (2018)</a>           | USA                | Management & Leadership                                                                                                                                                                                     | K                     | No info                    | Computer         | No info                                                                              | No info  | Yes       | Yes                                                                                | Certificate |
|                 | 55. <a href="#">van de Oudeweetering</a>        | The Netherlands    | Physical Science & Engineering,                                                                                                                                                                             | K                     | No info                    | No info          | No info                                                                              | No info  | Yes       | No info                                                                            | No info     |

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Table 4 (continued)

| Assessment type | Authors (year)                              | Country/<br>Region | Discipline                                                   | Cognitive<br>Outcomes | Assessment characteristics |          |                                                                    |          |           |                                                            |                     |
|-----------------|---------------------------------------------|--------------------|--------------------------------------------------------------|-----------------------|----------------------------|----------|--------------------------------------------------------------------|----------|-----------|------------------------------------------------------------|---------------------|
|                 |                                             |                    |                                                              |                       | Purpose                    | Assessor | Frequency                                                          | Feedback | Mandatory | Scoring                                                    | Reward              |
| Exam            | and Agirdag (2018)                          | The Netherlands    | Social Science, Data Science                                 | K                     | No info                    | Peer     | 1                                                                  | No info  | Yes       | No info                                                    | Certificate         |
|                 | 56. van den Beemt et al. (2018)             |                    | Data Science                                                 |                       |                            |          |                                                                    |          |           |                                                            |                     |
|                 | 9. Conijn et al. (2018)                     | The Netherlands    | Computer Science                                             | K                     | No info                    | No info  | 1 final exam                                                       | No info  | No        | No info                                                    | No info             |
|                 | 11. DeBoer et al. (2019)                    | USA                | Neuroscience, Engineering                                    | K                     | Summative                  | No info  | 1 final exam                                                       | No info  | Yes       | 100% of grade                                              | Certificate         |
|                 | 18. Jia et al. (2019)                       | China              | Medical Health                                               | K                     | No info                    | No info  | 1 final exam                                                       | No info  | Yes       | 50% of grade                                               | No info             |
|                 | 21. Kahan et al. (2017)                     | Israel             | Biology                                                      | K                     | Summative                  | No info  | 1 final exam                                                       | No info  | Yes       | 50% of grade                                               | Credit, certificate |
|                 | 28. Lee (2018)                              | USA                | Engineering                                                  | K                     | Summative                  | No info  | 1 midterm exam; 1 final exam                                       | No info  | Yes       | 23% of grade                                               | Certificate         |
|                 | 29. Lee (2019)                              | USA                | Engineering                                                  | K                     | Summative                  | Computer | 1 midterm exam; 1 final exam                                       | No info  | Yes       | 23% of grade                                               | Certificate         |
|                 | 31. Li and Moore (2018)                     | USA                | Chemistry                                                    | K                     | No info                    | No info  | 1 midterm exam; 1 final exam                                       | No info  | No        | No info                                                    | Certificate         |
|                 | 39. Najafi et al. (2017)                    | Canada             | Computer Science                                             | K                     | Summative                  | Computer | 1 final exam                                                       | No info  | Yes       | 50% of grade                                               | No info             |
| Survey          | 42. Patterson (2018)                        | USA                | No info                                                      | K                     | Summative                  | No info  | 1 final exam                                                       | No info  | Yes       | 45% of grade                                               | Certificate         |
|                 | 44. Qiu and Xu (2018)                       | USA                | Management & Leadership                                      | K                     | No info                    | Computer | 1 final exam                                                       | No info  | Yes       | No info                                                    | Certificate         |
|                 | 55. van de Oudeweetering and Agirdag (2018) | The Netherlands    | Physical Science & Engineering, Social Science, Data Science | K                     | No info                    | No info  | No info                                                            | No info  | Yes       | No info                                                    | No info             |
|                 | 60. Watson et al. (2017)                    | USA                | Social Science                                               | K                     | Summative                  | No info  | 1 midterm exam; 1 final exam                                       | No info  | Yes       | No info                                                    | Certificate         |
|                 | 13. Eccleston et al. (2019)                 | Australia          | No info                                                      | K                     | No info                    | Self     | 1 pre-survey; 1 post-survey                                        | No       | No        | No                                                         | No                  |
|                 | 41. Onah and Sinclair (2017)                | UK                 | Computer Science                                             | IS                    | No info                    | Self     | 1                                                                  | No       | No        | No                                                         | No                  |
| Assessment      | 14. Emanuel and Lamb (2017)                 | USA                | Art & Culture                                                | K                     | Formative                  | Computer | No info                                                            | No info  | Yes       | 50% of grade or greater                                    | Certificate         |
|                 | 16. Harvey et al. (2017)                    | Australia          | Healthcare                                                   | K; IS                 | No info                    | Self     | Self-assessments; the pre-MOOC and post-MOOC knowledge assessments | No info  | Yes       | Post-MOOC knowledge assessment contribute to 100% of grade | Certificate         |
|                 |                                             |                    | Health                                                       | K                     |                            |          |                                                                    | No info  |           | Yes                                                        | Certificate         |

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Table 4 (continued)

| Assessment type  | Authors (year)                  | Country/<br>Region | Discipline                                                                                                                                                                                                      | Cognitive<br>Outcomes | Assessment characteristics |                      |                                             |                     |                              |                                       |             |
|------------------|---------------------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------|----------------------|---------------------------------------------|---------------------|------------------------------|---------------------------------------|-------------|
|                  |                                 |                    |                                                                                                                                                                                                                 |                       | Purpose                    | Assessor             | Frequency                                   | Feedback            | Mandatory                    | Scoring                               | Reward      |
| Discussion forum | 27. Lan et al. (2019)           | China-Hong Kong    |                                                                                                                                                                                                                 |                       | Formative; Summative       | Computer; self; peer | 5; non-graded assessments                   |                     | Yes; not contribute to grade |                                       |             |
|                  | 49. Singh and Mørch (2018)      | Norway             | Nature & Environment                                                                                                                                                                                            | K                     | Formative                  | Peer                 | No info                                     | No info             | No info                      | No info                               | No info     |
|                  | 60. Watson et al. (2017)        | USA                | Social Science                                                                                                                                                                                                  | K                     | Formative                  | Self                 | 10                                          | No info             | No info                      | No info                               | No info     |
|                  | 18. Jia et al. (2019)           | China              | Medical Health                                                                                                                                                                                                  | K                     | No info                    | No info              | 3 case discussions                          | No info             | Yes                          | 10% of grade                          | No info     |
|                  | 39. Najafi et al. (2017)        | Canada             | Health, Computer Science, Social Science & Humanities                                                                                                                                                           | K; IS                 | Formative                  | Peer, instructor     | No info                                     | No info             | Yes                          | 10% of grade; not contribute to grade | No info     |
| Test             | 54. Torres and Beier (2018)     | USA                | No info                                                                                                                                                                                                         | K                     | No info                    | Instructor           | No info                                     | Yes                 | Yes                          | 40% of grade                          | Certificate |
|                  | 18. Jia et al. (2019)           | China              | Medical Health                                                                                                                                                                                                  | K                     | No info                    | No info              | 10 topic tests; in-class test               | No info             | No info                      | 40% of grade; not contribute to grade | No info     |
|                  | 38. Moreno-Marcos et al. (2018) | Spain              | Computer Science                                                                                                                                                                                                | K                     | No info                    | No info              | 5                                           | No info             | Yes                          | 75% of grade                          | No info     |
|                  | 39. Najafi et al. (2017)        | Canada             | Social Science & Humanities                                                                                                                                                                                     | K; IS                 | Formative                  | Computer             | 2 Web-based tests                           | Alternative answers | Yes                          | 90% of grade                          | No info     |
|                  | 64. Xing (2019)                 | USA                | Business & Management, Computer Science, Education, the Humanities, Mathematics & Statistics, the Medical Science, the Physical Science, the Professional & Applied Science, interdisciplinary and other fields | K                     | No info                    | No info              | No info                                     | No info             | No info                      | No info                               | No info     |
| Homework         | 25. Kovanović et al. (2019)     | Australia          | Computer Science                                                                                                                                                                                                | K; IS                 | No info                    | No info              | 11                                          | No info             | Yes                          | 40% of grade                          | Certificate |
| Checkpoints      | 28. Lee (2018)                  | USA                | Engineering                                                                                                                                                                                                     | K                     | Summative                  | No info              | No info                                     | No info             | Yes                          | 34% of grade                          | Certificate |
|                  | 29. Lee (2019)                  | USA                | Engineering                                                                                                                                                                                                     | K                     | Summative                  | Computer             | No info                                     | No info             | Yes                          | 34% of grade                          | Certificate |
|                  | 28. Lee (2018)                  | USA                | Engineering                                                                                                                                                                                                     | K                     | Formative                  | No info              | No info                                     | No info             | Yes                          | 8% of grade                           | Certificate |
| Exercise         | 29. Lee (2019)                  | USA                | Engineering                                                                                                                                                                                                     | K                     | Formative                  | Computer             | No info                                     | No info             | Yes                          | 8% of grade                           | Certificate |
|                  | 39. Najafi et al. (2017)        | Canada             | Computer Science                                                                                                                                                                                                | IS                    | Formative                  | Computer             | 7 exercises in Programming1; 4 exercises in | No info             | Yes                          | 35% of grade in Programming1; 60% in  | No info     |

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Table 4 (continued)

| Assessment type            | Authors (year)              | Country/<br>Region | Discipline                        | Cognitive<br>Outcomes | Assessment characteristics |            |                                                                                          |          |           |                                                                                                          |                        |
|----------------------------|-----------------------------|--------------------|-----------------------------------|-----------------------|----------------------------|------------|------------------------------------------------------------------------------------------|----------|-----------|----------------------------------------------------------------------------------------------------------|------------------------|
|                            |                             |                    |                                   |                       | Purpose                    | Assessor   | Frequency                                                                                | Feedback | Mandatory | Scoring                                                                                                  | Reward                 |
|                            |                             |                    |                                   |                       |                            |            | Programming2; 7<br>exercises in Stats                                                    |          |           | Programming2;<br>70% of grade in<br>Stats                                                                |                        |
|                            | 60. Watson et al. (2017)    | USA                | Social Science                    | K                     | Formative                  | No info    | No info                                                                                  | No info  | No info   | No info                                                                                                  | No info                |
| User data                  | 51. Sun and Bin (2018)      | China              | No info                           | IS                    | No info                    | Researcher | 1                                                                                        | No       | No        | No                                                                                                       | No                     |
| Course project             | 40. Najafi et al. (2018)    | Canada             | Computer Science                  | K                     | Summative                  | No info    | 1 in iOSApp1 and<br>iOSApp2,<br>respectively                                             | No info  | Yes       | 40% of grade,<br>respectively                                                                            | No info                |
| Course requirements        | 1. Almeda et al. (2018)     | USA                | Humanities                        | K                     | No info                    | Instructor | No info                                                                                  | No info  | Yes       | No info                                                                                                  | Credit,<br>badge       |
| Essay                      | 39. Najafi et al. (2017)    | Canada             | Social Science &<br>Humanities    | IS                    | Formative                  | Peer       | 1 essay in<br>IntroPsych;<br>1 essay in<br>AboriginalEd;<br>3 essays in Mental<br>Health | Rubrics  | Yes       | 10% of grade in<br>IntroPsych; 50% of<br>grade in<br>AboriginalEd;<br>100% of grade in<br>Mental Health. | No info                |
| Labs                       | 25. Kovanović et al. (2019) | Australia          | Computer Science                  | K; IS                 | No info                    | No info    | 7                                                                                        | No info  | Yes       | 60% of grade                                                                                             | Certificate            |
| Online activities          | 15. Formanek et al. (2017)  | USA                | Physical Science &<br>Engineering | K                     | No info                    | No info    | 2                                                                                        | No info  | Yes       | 20% of grade                                                                                             | No info                |
| Practical work             | 22. Khalil and Ebner (2017) | Austria            | No info                           | K                     | No info                    | No info    | 1                                                                                        | No info  | No info   | No info                                                                                                  | Credit,<br>certificate |
| Problem sets               | 31. Li and Moore (2018)     | USA                | Chemistry                         | K                     | No info                    | No info    | Optional bi-<br>weekly advanced<br>problem sets                                          | No info  | No        | No info                                                                                                  | Certificate            |
| Group embedded figure test | 6. Chang et al. (2019)      | China-Taiwan       | No info                           | K                     | No info                    | Computer   | 1                                                                                        | No info  | No info   | No info                                                                                                  | No info                |
| Writing projects           | 8. Comer (2017)             | USA                | Arts & Humanities                 | K; IS                 | Formative                  | Peer       | 4                                                                                        | Rubrics  | Yes       | 100% of grade                                                                                            | No info                |

Note: K = knowledge, IS = intellectual skills.

**Table 5**

An overview of assessment characteristics of behavioral outcomes in the studies reviewed.

| Assessment type | Authors (year)                      | Country/Region  | Discipline                                                                | Behavioral Outcomes | Assessment characteristics |           |         |          |           |         |        |
|-----------------|-------------------------------------|-----------------|---------------------------------------------------------------------------|---------------------|----------------------------|-----------|---------|----------|-----------|---------|--------|
|                 |                                     |                 |                                                                           |                     | Assessor                   | Frequency | Purpose | Feedback | Mandatory | Scoring | Reward |
| User data       | 1. Almeda et al. (2018)             | USA             | Humanities                                                                | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 2. Balint et al. (2017)             | USA             | Engineering                                                               | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 3. Bonafini (2017)                  | USA             | Education                                                                 | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 4. Bonafini et al. (2017)           | USA             | Physical Science & Engineering                                            | E; COM              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 7. Chiu and Hew (2018)              | China-Hong Kong | No info                                                                   | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 9. Conijn et al. (2018)             | The Netherlands | Computer Science                                                          | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 10. de Lima and Zorrilla (2017)     | Spain           | No info                                                                   | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 12. Duan et al. (2019)              | China           | No info                                                                   | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 14. Emanuel and Lamb (2017)         | USA             | Art & Culture                                                             | E; CER              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 16. Harvey et al. (2017)            | Australia       | Healthcare                                                                | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 18. Jia et al. (2019)               | China           | Medical Health                                                            | E; COM              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 21. Kahan et al. (2017)             | Israel          | Biology                                                                   | E; CER              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 22. Khalil and Ebner (2017)         | Austria         | No info                                                                   | E; COM; CER         | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 23. Kizilcec et al. (2017)          | USA             | Engineering, Computer Science, Management, Transportation, and Education. | E; CER              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 25. Kovanović et al. (2019)         | Australia       | Computer Science                                                          | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 27. Lan et al. (2019)               | China-Hong Kong | Health                                                                    | E; COM; CER         | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 28. Lee (2018)                      | USA             | Engineering                                                               | E; CER              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 29. Lee (2019)                      | USA             | Engineering                                                               | E; COM; CER         | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 30. Li and Baker (2018)             | USA             | Mathematics                                                               | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 35. Luo et al. (2018)               | China           | No info                                                                   | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 36. Maldonado-Mahauad et al. (2018) | Chile           | Engineering, Education, Management                                        | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 40. Najafi et al. (2018)            | Canada          | Computer Science                                                          | COM                 | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 42. Patterson (2018)                | USA             | No info                                                                   | E; COM; CER         | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 43. Poquet et al. (2018)            | Singapore       | Business & Management, Computer Science                                   | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 45. Rabin et al. (2019)             | The Netherlands | No info                                                                   | E; CER              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 46. Rizvi et al. (2019)             | UK              | Science                                                                   | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 52. Sunar et al. (2018)             | Turkey          | Study skills                                                              | E; COM              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 54. Torres and Beier (2018)         | USA             | No info                                                                   | E; COM              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 56. van den Beemt et al. (2018)     | The Netherlands | Data Science                                                              | E; CER              | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 58. Wang, Anderson, and Chen (2018) | China           | No info                                                                   | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 59. Wang, Hu, and Zhou (2018)       | China           | Engineering                                                               | E; COM; CER         | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 60. Watson et al. (2017)            | USA             | Social Science                                                            | CER                 | Researcher                 | 1         | No      | No       | No        | No      | No     |

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Table 5 (continued)

| Assessment type                  | Authors (year)                              | Country/Region    | Discipline                                                                                                                                                       | Behavioral Outcomes | Assessment characteristics |           |         |          |           |         |        |
|----------------------------------|---------------------------------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|----------------------------|-----------|---------|----------|-----------|---------|--------|
|                                  |                                             |                   |                                                                                                                                                                  |                     | Assessor                   | Frequency | Purpose | Feedback | Mandatory | Scoring | Reward |
| Survey                           | 61. Williams et al. (2018)                  | USA               | Humanities/Liberal Arts, STEM                                                                                                                                    | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                                  | 62. Wong et al. (2019)                      | The Netherlands   | No info                                                                                                                                                          | E                   | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                                  | 64. Xing (2019)                             | USA               | Business & Management, Computer Science, Education, Humanities, Mathematics & Statistics, Medical Sciences, Physical Sciences, Professional and Applied Sciences | COM                 | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                                  | 17. Hudson et al. (2019)                    | UK                | Science, Engineering & Math                                                                                                                                      | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 19. Jung and Lee (2018)                     | Republic of Korea | Psychology, Design, Humanities, Musicology, Physics                                                                                                              | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 23. Kizilcec et al. (2017)                  | USA               | Engineering, Computer Science, Management, Transportation, and Education.                                                                                        | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 33. Li et al. (2018)                        | China             | No info                                                                                                                                                          | COM                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 37. Meek et al. (2017)                      | UK                | Health & Psychology                                                                                                                                              | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 44. Qiu and Xu (2018)                       | USA               | Management & Leadership                                                                                                                                          | CER                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 49. Singh and Mørch (2018)                  | Norway            | Nature & Environment                                                                                                                                             | E; COM              | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 50. Stich and Reeves (2017)                 | USA               | No info                                                                                                                                                          | COM                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 53. Swinnerton et al. (2017)                | UK                | Health & Psychology                                                                                                                                              | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 55. van de Oudeweetering and Agirdag (2018) | The Netherlands   | Physical Science & Engineering, Social Science, Data Science                                                                                                     | COM                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                                  | 65. Yang and Su (2017)                      | China-Taiwan      | 2D Animation Production                                                                                                                                          | E                   | Self                       | 1         | No      | No       | No        | No      | No     |
| Interview<br>Observation         | 34. Loizzo et al. (2017)                    | USA               | No info                                                                                                                                                          | COM, CER            | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                                  | 49. Singh and Mørch (2018)                  | Norway            | Nature & Environment                                                                                                                                             | E; COM              | Researcher                 | 1         | No      | No       | No        | No      | No     |
| Group<br>embedded<br>figure test | 6. Chang et al. (2019)                      | China-Taiwan      | No info                                                                                                                                                          | E                   | Computer                   | 1         | No      | No       | No        | No      | No     |

Note: E = engagement, COM = course completion, CER = course certificate.

**Table 6**

An overview of assessment characteristics of affective outcomes in the studies reviewed.

| Assessment type | Authors (year)                     | Country/Region    | Discipline                                                                                                               | Affective Outcomes | Assessment characteristics |           |         |          |           |         |        |
|-----------------|------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------------|-----------|---------|----------|-----------|---------|--------|
|                 |                                    |                   |                                                                                                                          |                    | Assessor                   | Frequency | Purpose | Feedback | Mandatory | Scoring | Reward |
| Survey          | 5. Buhr et al. (2019)              | Canada            | Health                                                                                                                   | PE                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 10. de Lima and Zorrilla (2017)    | Spain             | No info                                                                                                                  | SAT                | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 11. DeBoer et al. (2019)           | USA               | Neuroscience, Engineering                                                                                                | PB                 | Self                       | 2         | No      | No       | No        | No      | No     |
|                 | 17. Hudson et al. (2019)           | UK                | Science, Engineering & Math                                                                                              | PB                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 19. Jung and Lee (2018)            | Republic of Korea | Psychology, Design, Humanities, Physics, Musicology,                                                                     | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 20. Jung et al. (2019)             | USA               | Personal Development                                                                                                     | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 22. Khalil and Ebner (2017)        | Austria           | No info                                                                                                                  | SAT                | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 24. Kormos and Nijakowska (2017)   | UK                | Teaching                                                                                                                 | PB; PE             | Self                       | 2         | No      | No       | No        | No      | No     |
|                 | 25. Kovanović et al. (2019)        | Australia         | Computer Science                                                                                                         | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 26. Krasny et al. (2018)           | USA               | No info                                                                                                                  | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 31. Li and Moore (2018)            | USA               | Chemistry                                                                                                                | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 32. Li (2019)                      | USA               | Social sciences, Arts & Humanities, Business, Health, Math & Logic, Physical Science & Engineering, Personal Development | PB; PE; SAT        | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 33. Li et al. (2018)               | China             | No info                                                                                                                  | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 37. Meek et al. (2017)             | UK                | Health & Psychology                                                                                                      | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 40. Najafi et al. (2018)           | Canada            | Computer Science                                                                                                         | PB                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 43. Poquet et al. (2018)           | Singapore         | Business & Management, Computer Science                                                                                  | PE                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 45. Rabin et al. (2019)            | The Netherlands   | No info                                                                                                                  | PB; PE; SAT        | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 47. Rodriguez and Armellini (2017) | Mexico            | Study skills                                                                                                             | PB                 | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 49. Singh and Mørch (2018)         | Norway            | Nature & Environment                                                                                                     | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 50. Stich and Reeves (2017)        | USA               | No info                                                                                                                  | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 |                                    | UK                | Health & Psychology                                                                                                      | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |

(continued on next page)

Table 6 (continued)

| Assessment type | Authors (year)                     | Country/Region | Discipline                                   | Affective Outcomes | Assessment characteristics |           |         |          |           |         |        |
|-----------------|------------------------------------|----------------|----------------------------------------------|--------------------|----------------------------|-----------|---------|----------|-----------|---------|--------|
|                 |                                    |                |                                              |                    | Assessor                   | Frequency | Purpose | Feedback | Mandatory | Scoring | Reward |
| Interview       | 53. Swinnerton et al. (2017)       | Mexico         | Engineering                                  | PB; SAT            | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 57. Valdivia Vázquez et al. (2018) |                |                                              |                    |                            |           |         |          |           |         |        |
|                 | 60. Watson et al. (2017)           | USA            | Social Science                               | PB; SAT            | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 65. Yang and Su (2017)             | China-Taiwan   | Art & Humanities                             | PB; PE             | Self                       | 1         | No      | No       | No        | No      | No     |
|                 | 17. Hudson et al. (2019)           | UK             | Science, Engineering & Math                  | PB                 | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 26. Krasny et al. (2018)           | USA            | No info                                      | PB; PE             | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 31. Li and Moore (2018)            | USA            | Chemistry                                    | PB; PE             | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 34. Loizzo et al. (2017)           | USA            | No info                                      | PB; PE             | Researcher                 | 1         | No      | No       | No        | No      | No     |
| Observation     | 48. Shapiro et al. (2017)          | USA            | Physical Science & Engineering, Data Science | PB; PE             | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 60. Watson et al. (2017)           | USA            | Social Sciences                              | PB                 | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 63. Wu et al. (2019)               | China-Taiwan   | Management & Leadership                      | PB                 | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 34. Loizzo et al. (2017)           | USA            | No info                                      | PB; PE             | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 3. Bonafini (2017)                 | USA            | Education                                    | PB                 | Self                       | 1         | No      | No       | No        | No      | No     |
| Self-assessment |                                    |                |                                              |                    |                            |           |         |          |           |         |        |
| User data       | 8. Comer (2017)                    | USA            | Arts & Humanities                            | PB                 | Researcher                 | 1         | No      | No       | No        | No      | No     |
|                 | 59. Wang, Hu, and Zhou (2018)      | China          | Engineering                                  | PE                 | Researcher                 | 1         | No      | No       | No        | No      | No     |

Note: PE = perceptions of MOOCs experience, PB = perceptions of MOOCs benefits, SAT = course satisfaction.

## References\*

- Alario-Hoyos, C., Pérez-Sanagustín, M., Delgado-Kloos, C., & Muñoz-Organero, M. (2014). Delving into participants' profiles and use of social tools in MOOCs. *IEEE Transactions on Learning Technologies*, 7(3), 260–266. <https://doi.org/10.1109/TLT.2014.2311807>
- Alexandron, G., Wiltrout, M. E., Berg, A., & Ruipérez-Valiente, J. A. (2020, March). Assessment that matters: Balancing reliability and learner-centered pedagogy in MOOC assessment. In *Proceedings of the tenth international conference on learning analytics & knowledge* (pp. 512–517). <https://doi.org/10.1145/3375462.3375464>
- \* Almeda, M. V., Zuech, J., Baker, R. S., Utz, C., Higgins, G., & Reynolds, R. (2018). Comparing the factors that predict completion and grades among for-credit and open/MOOC students in online learning. *Online Learning*, 22(1), 1–18. Retrieved from: <https://www.learnlib.org/p/189536/>.
- Admiraal, W., Huisman, B., & Pilli, O. (2015). Assessment in massive open online courses. *Electronic Journal of E-Learning*, 13(4), 1–18. Retrieved from: <https://files.eric.ed.gov/fulltext/EJ1062116.pdf>.
- \* Balint, T. A., Teodorescu, R., Colvin, K., Choi, Y. J., & Pritchard, D. (2017). Physics instructional resource usage by high-, medium-, and low-skilled MOOC students. *The Physics Teacher*, 55(4), 222–225. <https://doi.org/10.1119/1.4978719>.
- Barak, M., Watted, A., & Haick, H. (2016). Motivation to learn in massive open online courses: Examining aspects of language and social engagement. *Computers & Education*, 94, 49–60. <https://doi.org/10.1016/j.compedu.2015.11.010>
- \* van den Beemt, A., Buijs, J., van der Aalst, W., Henderson, S., Conrad, D., McGreal, R., et al. (2018). Analysing structured learning behaviour in massive open online courses (MOOCs): An approach based on process mining and clustering. *International Review of Research in Open and Distance Learning*, 19(5). <https://doi.org/10.19173/irrodl.v19i5.3748>.
- Bell, F. (2011). Connectivism: It's place in theory-informed research and innovation in technology-enabled learning. *International Review of Research in Open and Distance Learning*, 12(3), 98–118. <https://doi.org/10.19173/irrodl.v12i3.902>
- Bloom, B. S. (1956). *Taxonomy of educational objectives. Vol. 1: Cognitive domain*. New York: David McKay Company.
- Bloom, B. S., Englehart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1956). *Taxonomy of educational objectives. Handbook I: Cognitive domain*. New York: David McKay Company.
- \* Bonafini, F. C. (2017). The effects of participants' engagement with videos and forums in a MOOC for teachers' professional development. *Open Praxis*, 9(4), 433–447. <https://doi.org/10.5944/openpraxis.9.4.637>.
- \* Bonafini, F. C., Chae, C., Park, E., & Jablowski, K. (2017). How much does student engagement with videos and forums in a MOOC affect their achievement?. *Online Learning Journal*, 21(4), 223–240. Retrieved from <https://www.learnlib.org/p/183772/>.
- Bralić, A., & Divjak, B. (2018). Integrating MOOCs in traditionally taught courses: Achieving learning outcomes with blended learning. *International Journal of Educational Technology in Higher Education*, 15(1), 2. <https://doi.org/10.1186/s41239-017-0085-7>
- \* Buhr, E. E., Daniels, L. M., & Goegan, L. D. (2019). Cognitive appraisals mediate relationships between two basic psychological needs and emotions in a massive open online course. *Computers in Human Behavior*, 96, 85–94. <https://doi.org/10.1016/j.chb.2019.02.009>.
- \* Chang, J. J., Lin, W. S., & Chen, H. R. (2019). How attention level and cognitive style affect learning in a MOOC environment? Based on the perspective of brainwave analysis. *Computers in Human Behavior*, 100, 209–217. <https://doi.org/10.1016/j.chb.2018.08.016>.
- Chauhan, A. (2014). Massive open online courses (MOOCs): Emerging trends in assessment and accreditation. *Digital Education Review*, (25), 7–17. <https://doi.org/10.1344/der.2014.25.7-17>
- \* Chiu, T. K. F., & Hew, T. K. F. (2018). Factors influencing peer learning and performance in MOOC asynchronous online discussion forum. *Australasian Journal of Educational Technology*, 34(4), 16. <https://doi.org/10.14742/ajet.3240>.
- Clark, R. A. (2002). Learning outcomes: The bottom line. *Communication Education*, 51(4), 396–404. <https://doi.org/10.1080/03634520216531>
- \* Comer, D. (2017). Learning transfer, feedback, and massive open online courses. *Journal of Systemics, Cybernetics and Informatics*, 15(1), 44–52. Retrieved from: [http://www.iijsci.org/Journal/CV\\$/sci/pdfs/SA611XH16.pdf](http://www.iijsci.org/Journal/CV$/sci/pdfs/SA611XH16.pdf).
- \* Conijn, R., Van Den Beemt, A., & Cuijpers, P. (2018). Predicting student performance in a blended MOOC. *Journal of Computer Assisted Learning*, 34(5), 615–628. <https://doi.org/10.1111/jcal.12270>.
- Dale, V. H., & Singer, J. (2019). Learner experiences of a blended course incorporating a MOOC on Haskell functional programming. *Research in Learning Technology*, 27. <https://doi.org/10.25304/rlt.v27.2248>
- Dandache, S., Frenay, M., Van Nes, M. C., & Verschuren, F. (2017). A massive open online course (MOOC) for implementing pedagogical tools in undergraduate respiratory physiology. *HAPS Educator*, 21(2), 36–42. <https://doi.org/10.21692/haps.2017.013>
- Day, I. N., van Blankenstein, F. M., Westenberg, M., & Admiraal, W. (2018). A review of the characteristics of intermediate assessment and their relationship with student grades. *Assessment & Evaluation in Higher Education*, 43(6), 908–929. Retrieved from: <https://doi.org/10.1080/02602938.2017.1417974>.
- \* DeBoer, J., Haney, C., Atiq, S. Z., Smith, C., & Cox, D. (2019). Hands-on engagement online: Using a randomised control trial to estimate the impact of an at-home lab kit on student attitudes and achievement in a MOOC. *European Journal of Engineering Education*, 44(1–2), 234–252. <https://doi.org/10.1080/03043797.2017.1378170>.
- Deng, R., Benckendorff, P., & Gannaway, D. (2019). Progress and new directions for teaching and learning in MOOCs. *Computers & Education*, 129, 48–60. <https://doi.org/10.1016/j.compedu.2018.10.019>
- Deng, R., Benckendorff, P., & Gannaway, D. (2020). Linking learner factors, teaching context, and engagement patterns with MOOC learning outcomes. *Journal of Computer Assisted Learning*, 36, 688–708. <https://doi.org/10.1111/jcal.12437>
- Downes, S. (2008). Places to go: Connectivism & connective knowledge. *Innovate Journal of Online Education*, 5(1), 6. Retrieved from: <https://nsuworks.nova.edu/cgi/viewcontent.cgi?article=1037&context=innovate/>.
- \* Duan, J., Xie, K., Hawk, N. A., Yu, S., & Wang, M. (2019). Exploring a personal social knowledge network (PSKN) to aid the observation of connectivist interaction for high- and low-performing learners in connectivist massive open online courses. *British Journal of Educational Technology*, 50(1), 199–217. <https://doi.org/10.1111/bjet.12687>.
- Ebben, M., & Murphy, J. S. (2014). Unpacking MOOC scholarly discourse: A review of nascent MOOC scholarship. *Learning, Media and Technology*, 39(3), 328–345. <https://doi.org/10.1080/17439884.2013.878352>
- \* Eccleston, C., Doherty, K., Bindoff, A., Robinson, A., Vickers, J., & McInerney, F. (2019). Building dementia knowledge globally through the understanding dementia Massive Open Online Course (MOOC). *npj Science of Learning*, 4(1), 1–6. <https://doi.org/10.1038/s41539-019-0042-4>.
- \* Emanuel, J. P., & Lamb, A. (2017). Open, online, and blended: Transactional interactions with MOOC content by learners in three different course formats. *Online Learning*, 21(2), n2.
- Ewais, A., Awad, M., & Hadia, K. (2020). Aligning learning materials and assessment with course learning outcomes in MOOCs using data mining techniques. In I. Hatzilygeroudis, I. Perikos, & F. Grivokostopoulou (Eds.), *Advances in integrations of intelligent methods. Smart innovation, systems and technologies* (Vol. 170, pp. 1–25). Singapore: Springer. [https://doi.org/10.1007/978-981-15-1918-5\\_1](https://doi.org/10.1007/978-981-15-1918-5_1).
- \* Formanek, M., Wenger, M. C., Buxner, S. R., Impey, C. D., & Sonam, T. (2017). Insights about large-scale online peer assessment from an analysis of an astronomy MOOC. *Computers & Education*, 113, 243–262. <https://doi.org/10.1016/j.compedu.2017.05.019>.
- \* Harvey, L. A., Glinsky, J. V., Muldoon, S., & Chhabra, H. S. (2017). Massive open online courses for educating physiotherapists about spinal cord injuries: A descriptive study. *Spinal Cord Series and Cases*, 3, 17005. <https://doi.org/10.1038/scsanc.2017.5>.
- Hendriks, R. A., de Jong, Admiraal, W. F., & Reinders, M. E. (2020). Instructional design quality in medical massive open online courses for integration into campus education. *Medical Teacher*, 42(2), 156–163. <https://doi.org/10.1080/0142159X.2019.1665634>.

\* Note: the articles synthesized in the literature review are designated by an asterisk.

- Huisman, B., Admiraal, W., Pilli, O., van de Ven, M., & Saab, N. (2018). Peer assessment in MOOCs: The relationship between peer reviewers' ability and authors' essay performance. *British Journal of Educational Technology*, 49(1), 101–110. <https://doi.org/10.1111/bjet.12520>.
- \* Hudson, L., Wolff, A., Gooch, D., Van Der Linden, J., Kortuem, G. W., Petre, M., et al. (2019). Supporting urban change: Using a MOOC to facilitate attitudinal learning and participation in smart cities. *Computers & Education*, 129, 37–47. <https://doi.org/10.1016/j.compedu.2018.10.012>.
- \* Jia, M., Gong, D., Luo, J., Zhao, J., Zheng, J., & Li, K. (2019). Who can benefit more from massive open online courses? A prospective cohort study. *Nurse Education Today*, 76, 96–102. <https://doi.org/10.1016/j.nedt.2019.02.004>.
- \* Jung, E., Kim, D., Yoon, M., Park, S., & Oakley, B. (2019). The influence of instructional design on learner control, sense of achievement, and perceived effectiveness in a super-size MOOC course. *Computers & Education*, 128, 377–388. <https://doi.org/10.1016/j.compedu.2018.10.001>.
- \* Jung, Y., & Lee, J. (2018). Learning engagement and persistence in massive open online courses (MOOCs). *Computers & Education*, 122, 9–22. <https://doi.org/10.1016/j.compedu.2018.02.013>.
- Jung, I., & Lee, J. (2020). The effects of learner factors on MOOC learning outcomes and their pathways. *Innovations in Education & Teaching International*, 57(5), 565–576. <https://doi.org/10.1080/14703297.2019.1628800>.
- \* Kahan, T., Soffer, T., & Nachmias, R. (2017). Types of participant behavior in a massive open online course. *International Review of Research in Open and Distance Learning*, 18(6), 1–18. <https://doi.org/10.19173/irrodl.v18i6.3087>.
- \* Khalil, M., & Ebner, M. (2017). Clustering patterns of engagement in massive open online courses (MOOCs): The use of learning analytics to reveal student categories. *Journal of Computing in Higher Education*, 29(1), 114–132. <https://doi.org/10.1007/s12528-016-9126-9>.
- \* Kizilcec, R. F., Pérez-Sanagustín, M., & Maldonado, J. J. (2017). Self-regulated learning strategies predict learner behavior and goal attainment in massive open online courses. *Computers & Education*, 104, 18–33. <https://doi.org/10.1016/j.compedu.2016.10.001>.
- \* Kormos, J., & Nijakowska, J. (2017). Inclusive practices in teaching students with dyslexia: Second language teachers' concerns, attitudes and self-efficacy beliefs on a massive open online learning course. *Teaching and Teacher Education*, 68, 30–41. <https://doi.org/10.1016/j.tate.2017.08.005>.
- \* Kovanović, V., Joksimović, S., Poquet, O., Hennis, T., de Vries, P., Hatala, M., et al. (2019). Examining communities of inquiry in massive open online courses: The role of study strategies. *The Internet and Higher Education*, 40, 20–43. <https://doi.org/10.1016/j.iheduc.2018.09.001>.
- \* Krasny, M. E., DuBois, B., Adameit, M., Atiogbe, R., Alfakihuddin, M. L. B., Bold-erdene, T., et al. (2018). Small groups in a social learning MOOC (sIMOOC): Strategies for fostering learning and knowledge creation. *Online Learning*, 22(2), 119–139. Retrieved from: <https://files.eric.ed.gov/fulltext/EJ1181445.pdf>.
- \* Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). *Taxonomy of educational objectives: The affective domain, Handbook II*. New York: David McKay Company.
- \* Lan, M., Hou, X., Qi, X., & Mattheos, N. (2019). Self-regulated learning strategies in world's first MOOC in implant dentistry. *European Journal of Dental Education*, 23(3), 278–285. <https://doi.org/10.1111/eje.12428>.
- \* Lee, Y. (2018). Effect of uninterrupted time-on-task on students' success in massive open online courses (MOOCs). *Computers in Human Behavior*, 86, 174–180. <https://doi.org/10.1016/j.chb.2018.04.043>.
- \* Lee, Y. (2019). Using self-organizing map and clustering to investigate problem-solving patterns in the massive open online course: An exploratory study. *Journal of Educational Computing Research*, 57(2), 471–490. <https://doi.org/10.1177/0735633117753364>.
- \* Li, K. (2019). MOOC learners' demographics, self-regulated learning strategy, perceived learning and satisfaction: A structural equation modeling approach. *Computers & Education*, 132, 16–30. <https://doi.org/10.1016/j.compedu.2019.01.003>.
- \* Li, Q., & Baker, R. (2018). The different relationships between engagement and outcomes across participant subgroups in massive open online courses. *Computers & Education*, 127, 41–65. <https://doi.org/10.1016/j.compedu.2018.08.005>.
- Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P., et al. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *British Medical Journal*, 339, b2700. <https://doi.org/10.1136/bmj.b2700>.
- \* de Lima, M., & Zorrilla, M. E. (2017). Social networks and the building of learning communities: An experimental study of a social MOOC. *International Review of Research in Open and Distance Learning*, 18(1), 40–64. <https://doi.org/10.19173/irrodl.v18i1.2630>.
- \* Li, K., & Moore, D. R. (2018). Motivating students in massive open online courses (MOOCs) using the attention, relevance, confidence, satisfaction (ARCS) model. *Journal of Formative Design in Learning*, 2(2), 102–113. <https://doi.org/10.1007/s41686-018-0021-9>.
- Littenberg-Tobias, J., & Reich, J. (2020). Evaluating access, quality, and equity in online learning: A case study of a MOOC-based blended professional degree program. *The Internet and Higher Education*, 47, 100759. <https://doi.org/10.1016/j.iheduc.2020.100759>.
- \* Li, B., Wang, X., & Tan, S. C. (2018). What makes MOOC users persist in completing MOOCs? A perspective from network externalities and human factors. *Computers in Human Behavior*, 85, 385–395. <https://doi.org/10.1016/j.chb.2018.04.028>.
- \* Loizzo, J., Ertmer, P. A., Watson, W. R., & Watson, S. L. (2017). Adult MOOC learners as self-directed: Perceptions of motivation, success, and completion. *Online Learning*, 21(2), n2. <https://doi.org/10.24059/olj.v21i2.889>.
- \* Luo, Y., Zhou, G., Li, J., & Xiao, X. (2018). Study on MOOC scoring algorithm based on Chinese University MOOC learning behavior data. *Heliyon*, 4(11), Article e00960. <https://doi.org/10.1016/j.heliyon.2018.e00960>.
- \* Maldonado-Mahauad, J., Pérez-Sanagustín, M., Kizilcec, R. F., Morales, N., & Munoz-Gama, J. (2018). Mining theory-based patterns from big data: Identifying self-regulated learning strategies in massive open online courses. *Computers in Human Behavior*, 80, 179–196. <https://doi.org/10.1016/j.chb.2017.11.011>.
- del Mar Sánchez-Vera, M., & Prendes-Espinoza, M. P. (2015). Beyond objective testing and peer assessment: Alternative ways of assessment in MOOCs. *International Journal of Educational Technology in Higher Education*, 12(1), 119–130. <https://doi.org/10.7238/rusc.v12i1.2262>.
- \* Meek, S. E., Blakemore, L., & Marks, L. (2017). Is peer review an appropriate form of assessment in a MOOC? Student participation and performance in formative peer review. *Assessment & Evaluation in Higher Education*, 42(6), 1000–1013. <https://doi.org/10.1080/02602938.2016.1221052>.
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7), Article e1000097. <https://doi.org/10.1371/journal.pmed.1000097>.
- \* Moreno-Marcos, P. M., Muñoz-Merino, P. J., Alario-Hoyos, C., Estévez-Ayres, I., & Delgado Kloos, C. (2018). Analysing the predictive power for anticipating assignment grades in a massive open online course. *Behaviour & Information Technology*, 37(10–11), 1021–1036. <https://doi.org/10.1080/0144929X.2018.1458904>.
- \* Najafi, H., Rolheiser, C., Håklev, S., & Harrison, L. (2017). Variations in pedagogical design of massive open online courses (MOOCs) across disciplines. *Teaching & Learning Inquiry*, 5(2), 47–64. <https://doi.org/10.20343/teachlearningq.5.2.5>.
- \* Najafi, H., Rolheiser, C., Harrison, L., & Heikoop, W. (2018). Connecting learner motivation to learner progress and completion in massive open online courses. *Canadian Journal of Learning and Technology*, 44(2). <https://doi.org/10.21432/cjlt27559>, n2.
- Pilli, O., & Admiraal, W. (2016). A taxonomy of massive open online courses. *Contemporary Educational Technology*, 7(3), 223–240. <https://doi.org/10.30935/cedtech/6174>.
- Pilli, O., & Admiraal, W. (2017). Students' learning outcomes in massive open online courses (MOOCs): Some suggestions for course design. *Journal of Higher Education/Yükseköğretim Dergisi*, 7(1). <https://doi.org/10.2399/yod.17.001>.
- Post, L. S., Guo, P., Saab, N., & Admiraal, W. (2019). Effects of remote labs on cognitive, behavioral, and affective learning outcomes in higher education. *Computers & Education*, 140, 103596. <https://doi.org/10.1016/j.compedu.2019.103596>.
- \* Onah, D., & Sinclair, J. (2017). Assessing self-regulation of learning dimensions in a stand-alone MOOC platform. *International Journal of Engineering Pedagogy*, 7(2), 4–21. <https://www.learnlib.org/p/207403/>.
- \* van de Oudeweetering, K., & Agirdag, O. (2018). Demographic data of MOOC learners: Can alternative survey deliveries improve current understandings?. *Computers & Education*, 122, 169–178. <https://doi.org/10.1016/j.compedu.2018.03.017>.
- Papathoma, T., Blake, C., Clow, D., & Scanlon, E. (2015). Investigating learners' views of assessment types in massive open online courses (MOOCs). In G. Conole, T. Klobučar, C. Rensing, J. Konert, & E. Lavoué (Eds.), *Design for teaching and learning in a networked world. EC-TEL 2015. Lecture notes in computer science* (Vol. 9307, pp. 617–621). Cham: Springer. [https://doi.org/10.1007/978-3-319-24258-3\\_72](https://doi.org/10.1007/978-3-319-24258-3_72).
- \* Patterson, R. W. (2018). Can behavioral tools improve online student outcomes? Experimental evidence from a massive open online course. *Journal of Economic Behavior & Organization*, 153, 293–321. <https://doi.org/10.1016/j.jebo.2018.06.017>.

- \* Poquet, O., Kovanović, V., de Vries, P., Hennis, T., Joksimović, S., Gašević, D., et al. (2018). Social presence in massive open online courses. *International Review of Research in Open and Distance Learning*, 19(3). <https://doi.org/10.19173/irrodl.v19i3.3370>.
- \* Qiu, M., & Xu, Y. (2018). Assessing learning outcomes of a MOOC incorporated into an on-campus management information systems class. *Journal of International Technology and Information Management*, 27(1), 116–128. Available at: <https://scholarworks.lib.csusb.edu/jitim/vol27/iss1/5>.
- \* Rabin, E., Kalman, Y. M., & Kalz, M. (2019). An empirical investigation of the antecedents of learner-centered outcome measures in MOOCs. *International Journal of Educational Technology in Higher Education*, 16(1), 14. <https://doi.org/10.1186/s41239-019-0144-3>.
- Rayyan, S., Fredericks, C., Colvin, K. F., Liu, A., Teodorescu, R., Barrantes, A., et al. (2016). A MOOC based on blended pedagogy. *Journal of Computer Assisted Learning*, 32(3), 190–201. <https://doi.org/10.1111/jcal.12126>.
- \* Rizvi, S., Rienties, B., Rogaten, J., & Kizilcec, R. F. (2019). Investigating variation in learning processes in a FutureLearn MOOC. *Journal of Computing in Higher Education, Early-Access*. <https://doi.org/10.1007/s12528-019-09231-0>.
- \* Rodriguez, B. P., & Armellini, A. (2017). Developing self-efficacy through a massive open online course on study skills. *Open Praxis*, 9(3), 335–343. <https://doi.org/10.5944/openpraxis.9.3.659>.
- Sa'don, N. F., Alias, R. A., & Ohshima, N. (2014). Nascent research trends in MOOCs in higher educational institutions: A systematic literature review. In *Paper presented at the 2014 international conference on web and open access to learning (ICWOAL)* (pp. 1–4). IEEE. <https://doi.org/10.1109/ICWOAL.2014.7009215>.
- Sandeen, C. (2013). Assessment's place in the new MOOC world. *Research & Practice in Assessment*, 8, 5–12. Retrieved from: <https://files.eric.ed.gov/fulltext/EJ1062706.pdf>.
- \* Shapiro, H. B., Lee, C. H., Roth, N. E. W., Li, K., Çetinkaya-Rundel, M., & Canelas, D. A. (2017). Understanding the massive open online course (MOOC) student experience: An examination of attitudes, motivations, and barriers. *Computers & Education*, 110, 35–50. <https://doi.org/10.1016/j.compedu.2017.03.003>.
- Shavelson, R. J., & Huang, L. (2003). Responding responsibly. *Change. The Magazine of Higher Learning*, 35(1), 10–19. <https://doi.org/10.1080/00091380309604739>.
- \* Singh, A. B., & Mørch, A. I. (2018). An analysis of participants' experiences from the first international MOOC offered at the University of Oslo. *Nordic Journal of Digital Literacy*, 13(1), 40–64. <https://doi.org/10.18261/issn.1891-943x-2018-01-04>.
- \* Stich, A. E., & Reeves, T. D. (2017). Massive open online courses and underserved students in the United States. *The Internet and Higher Education*, 32, 58–71. <https://doi.org/10.1016/j.iheduc.2016.09.001>.
- \* Sunar, A. S., Abbasi, R. A., Davis, H. C., White, S., & Aljohani, N. R. (2018). Modelling MOOC learners' social behaviours. *Computers in Human Behavior*. <https://doi.org/10.1016/j.chb.2018.12.013>, 105835.
- \* Sun, G., & Bin, S. (2018). Topic interaction model based on local community detection in MOOC discussion forums and its teaching application. *Kuram ve Uygulamada Eğitim Bilimleri*, 18(6), 2922–2931. <https://doi.org/10.12738/estp.2018.6.191>.
- Sun, J. C. Y., & Rueda, R. (2012). Situational interest, computer self-efficacy and self-regulation: Their impact on student engagement in distance education. *British Journal of Educational Technology*, 43(2), 191–204. <https://doi.org/10.1111/j.1467-8535.2010.01157.x>.
- \* Swinnerton, B. J., Morris, N. P., Hotchkiss, S., & Pickering, J. D. (2017). The integration of an anatomy massive open online course (MOOC) into a medical anatomy curriculum. *Anatomical Sciences Education*, 10(1), 53–67. <https://doi.org/10.1002/ase.1625>.
- \* Torres, W. J., & Beier, M. E. (2018). Adult development in the wild: The determinants of autonomous learning in a massive open online course. *Learning and Individual Differences*, 65, 207–217. <https://doi.org/10.1016/j.lindif.2018.06.003>.
- \* Valdivia Vázquez, J. A., Ramírez-Montoya, M. S., Valenzuela González, J. R., Henderson, S., Conrad, D., McGreal, R., et al. (2018). Motivation and knowledge: Pre-assessment and post-assessment of MOOC participants from an energy and sustainability project. *International Review of Research in Open and Distance Learning*, 19(4), 116–132. <https://doi.org/10.19173/irrodl.v19i4.3489>.
- Vera, M. D. M. S., Calatayud, V. G., & Espinosa, M. P. P. (2017). The MOOC and student assessment: Systematic review (2012–2016). @tic. *Revista d'Innovació Educativa*, 18(1), 65. <https://doi.org/10.7203/attic.18.10013>.
- \* Wang, Z., Anderson, T., & Chen, L. (2018). How learners participate in connectivist learning: An analysis of the interaction traces from a cMOOC. *International Review of Research in Open and Distance Learning*, 19(1). <https://doi.org/10.19173/irrodl.v19i1.3269>.
- \* Wang, L., Hu, G., & Zhou, T. (2018). Semantic analysis of learners' emotional tendencies on online MOOC education. *Sustainability*, 10(6), 1921. <https://doi.org/10.3390/su10061921>.
- \* Watson, S. L., Watson, W. R., Yu, J. H., Alamri, H., & Mueller, C. (2017). Learner profiles of attitudinal learning in a MOOC: An explanatory sequential mixed methods study. *Computers & Education*, 114, 274–285. <https://doi.org/10.1016/j.compedu.2017.07.005>.
- \* Williams, K. M., Stafford, R. E., Corliss, S. B., & Reilly, E. D. (2018). Examining student characteristics, goals, and engagement in massive open online courses. *Computers & Education*, 126, 433–442. <https://doi.org/10.1016/j.compedu.2018.08.014>.
- \* Wong, J., Khalil, M., Baars, M., de Koning, B. B., & Paas, F. (2019). Exploring sequences of learner activities in relation to self-regulated learning in a massive open online course. *Computers & Education*, 140, 103595. <https://doi.org/10.1016/j.compedu.2019.103595>.
- \* Wu, W. H., Kao, H. Y., Wu, S. H., & Wei, C. W. (2019). Development and evaluation of affective domain using student's feedback in entrepreneurial MOOC courses. *Frontiers in Psychology*, 10, 1109. <https://doi.org/10.3389/fpsyg.2019.01109>.
- \* Xing, W. (2019). Exploring the influences of MOOC design features on student performance and persistence. *Distance Education*, 40(1), 98–113. <https://doi.org/10.1080/01587919.2018.1553560>.
- Xiong, Y., & Suen, H. K. (2018). Assessment approaches in massive open online courses: Possibilities, challenges and future directions. *International Review of Education*, 64(2), 241–263. <https://doi.org/10.1007/s11159-018-9710-5>.
- \* Yang, H. H., & Su, C. H. (2017). Learner behavior in a MOOC practice-oriented course: In empirical study integrating TAM and TPB. *International Review of Research in Open and Distance Learning*, 18(5), 35–63. <https://doi.org/10.19173/irrodl.v18i5.2991>.
- Yousef, A. M. F., Chatti, M. A., Schroeder, U., & Wosnitza, M. (2014, July). What drives a successful MOOC? An empirical examination of criteria to assure design quality of MOOCs. In *Proceedings of the 2014 IEEE 14th international conference on advanced learning technologies* (pp. 44–48). <https://doi.org/10.1109/ICALT.2014.23>.
- Yuan, L., Powell, S., & Olivier, B. (2014). *Beyond MOOCs: Sustainable online learning in institutions*. <https://e-space.mmu.ac.uk/id/eprint/619736>.
- Zheng, S., Rosson, M. B., Shih, P. C., & Carroll, J. M. (2015, February). Understanding student motivation, behaviors and perceptions in MOOCs. In *Proceedings of the 18th ACM conference on computer supported cooperative work & social computing* (pp. 1882–1895). <https://doi.org/10.1145/2675133.2675217>.
- Zhu, M., Sari, A., & Lee, M. M. (2018). A systematic review of research methods and topics of the empirical MOOC literature (2014–2016). *The Internet and Higher Education*, 37, 31–39. <https://doi.org/10.1016/j.iheduc.2018.01.002>.