Enhancing MOOCs peer reviews validity and reliability by a fuzzy coherence measure

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ABSTRACT

Massive Open Online Course (MOOC) are gaining more and more popularity permitting a large access for education. In doing so, they are confronted to new challenges, such as assessing a huge number of participants. A common idea lies on peer reviewing. However, students are not formed to assess others contributions. Hence, their evaluation are unreliable and may be biased. Since peer reviewing imposes itself in the actual MOOCs context, several approaches were considered to improve some aspects of its outcome. Here we proposed a fuzzy based approach that aims enhancing validity and reliability.

KEYWORDS

Validity, Reliability, Group Decision Making, Massive Open Online Course, Peer Reviewing, Fuzzy logic, Weighting Opinions.

1 INTRODUCTION

Facing a rapidly changing environment, education must adopt to the society needs [1]. MOOCs might be an appropriate solution to the emerging learning necessities: overcrowded class, college affordability to under developed counties and so forth [2].

MOOCs, in most of cases, consist of pre-recorded lectures and online quizzes [3], permitting an open access to numerous students. While class size can attain thousand learners, the notion of open might be debateful [4], Pomerol et al. [5] insisted that the word open means only, accessible to everyone. However, the software and the content might not be open, “open source”[6], “open access”[7]. Open does not mean free either [8].

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Since it is not just a distribution of educative content online [9], the process requires a pedagogical evolving scheme, including exercises and quizzes, raising the question of how can thousand students be assessed by a handful staff/teachers. While Multiple Choice Questions (MCQ) can give quantitative assessments, they cannot cover all learning aspects. Writing, analyzing are among other aspects that cannot be evaluated through any form of MCQ, imposing the use of qualitative criteria. Facing the large number of users in MOOCs, the evaluation of thousands learners can either function by a very sophisticated software or via a low cost and widely used solution, which is peer review by other participants [10].

While some authors claimed that MOOC learners aren’t supposed to be assessors [11]. Others maintained that facing the lack of developed software that can evaluate a quantitative tasks. The large number of learners cannot be assessed except by peer reviewing [12]. Furthermore, this process may enhance the learners engagement and comprehension [13]. Mulder et al. [14] studied the benefits effects of peer reviews on the learning process result. They also linked the peer review content to student perceptions and assessment grades. Meek et al. [15] investigated peer reviewing adequacy to MOOCs. However, peers assessments aren’t trustworthy [16], since the judges are novices evaluating other novices, that may share the same errors and misconceptions. Ashton and Davies [3] showed that a predefined scoring rubrics can result on more reliable assessments. James et al. [17] studied different aggregation operators aiming to release biased marks. In the same sense, we propose a method to permit elevating consistent opinions. Since the new referees have only a vague conception about the studied subjects.

We review peer reviewing methods in Chapter 2. The use of fuzzy logic in MOOCs to model human reasoning and the proposed methodology to improve validity and reliability of peer reviews is introduced in Chapter 3. Chapter 4 presents illustrative examples. While Chapter 5 concludes this work.

2 Peer Evaluation

MOOCs have been proposed as an alternative to classical learning [18], that can unveil new opportunities for higher education [19,20] and professional training [21,22], especially in underdeveloped countries [23].

As it may be expected, MOOCs suffered many criticisms [24–26]. Many authors pointed the low completion rate [27–29]. Deng et al. [30] linked students engagement to the learning outcome. Zhao et al. [31] questioned MOOCs learning quality pointing also the low completion rate. Other issues on quality evaluations in MOOCs were treated in [32,33]. Marshall [34] states that MOOCs are repeating the same errors encountered in classical education. Royatt et al. [35] claimed that certain MOOCs suffer pedagogical issues with unrealistic expectations especially for beginners. Ichou [36] argued that despite the fact that MOOCs can eliminate the cost barrier in the learning process, the beneficent students are generally advantaged in term of education. Resulting in minor impact on the initially targeted students. Steels [37], pointed the contextualization dilemma in MOOCs, mentioning that only classical subjects such as mathematics can be developed for all people around the globe, however certain courses might be successful just to a restricted group of students. Mentioning also that financial issues are still to be solved [5,38,39], and that no alternative solutions, even MOOCs, can replace "the real" contact between the teacher and the learners [40].

We have been familiarized during our respective learning processes to assessments. However this task is not as simple as it may appear, it can demonstrate the teachers' abilities as well as students' level [41]. Imposing a high quality assessment outcome [42]. The astronomic number of MOOCs learners, reduces the feasible assessment methodologies. Various learning assessment methodologies were proposed for MOOCs [43,44]. Since quantitative results are assessed through MCQ [45], qualitative ones such as writing and analyzing in this context can only be assessed via a developed software or peers [46]. Stating that MOOCs are supposed to be free for people that do not want a certificate and the exorbitant cost to develop efficient software, the peer reviewing alternative imposes itself in actual context. An overview of assessment techniques in large groups is presented in [47].

Peer reviewing have numerous applications, it can be used to improve performances [48], and even to evaluate teachers themselves [49,50]. In most of cases, the process engages experts. Noting that teachers evaluations themselves are to be reexamined [51], how can we trust learners assessments! Assuming that learners assimilate well the studied subject and the assessment procedure, collusions can bias the peer evaluation outcome. Song et al. [52] studied two types of collusions, in the first, which they call small circles, a small number of students who are reviewing each other's work, are attempted to increase the peer reviews grades. While in the second, called pervasive collusion, the evaluators give high marks to all, without knowing each other necessarily. The authors [52] have proposed an algorithm to estimate the inflation caused by colluders.

Peer evaluation benefits also are undeniable [53], as well as its drawbacks [54,55]. Since the actual context, which can rapidly change [56], imposes peer reviewing, several authors tempted to enhance the current methods [10,16,46,57,58]. First, let us define self-assessment and peer assessment.

Self-assessment consists of judging its own work according to given criteria. While in peer assessment, the participants are asked to review their peers' work, the peer assessment methods can contains only peer assessment as it may include also self-assessment. A comprehensive review of pros and cons of self and peer assessment was developed in [59]. A larger comparison involving teachers assessment to students in additions to the previous two aspects was proposed in [60].

Jackson and Marks [57] tried to improve post-graduated masters student by assessed reflections and grade withholding, they showed in their experience that a slight majority was sustaining grade withholding believing it help them analyze carefully the delivered feedback. They also showed that feedback quality correlated with grades improvements.

Staubitz et al. [46] maintained on the usefulness of peer assessment, and the difficulties encountered such as grading accuracy and rogue reviewers. They requested encouraging the practice by permitting self-assessed bonus point.

Gamage et al. [58] claimed that non-blind peer assessment can afford a high quality review, since permitting extended and consistent debates and avoiding harsh reviews that can be sent behind the vail of anonymity.

Numerous authors [3,10,61] insisted on the role of helping assessors by predefined notation scales, which can improve reliability and validity of the expressed reviews.

Suen [16] claimed that there is a necessity to combine several peer assessment methods in order to achieve accurate results.

An overview of peer assessment methods and future development is proposed in [62].

3 Fuzzy logic in MOOCs

A legitimate question can be formulated as follows: How to model assessors' opinions? Especially when their knowledge is vague and imprecise. Fuzzy logic [63] aims to model human uncertainties, particularly in decision making situations [64]. Capuano et al. [65] uses fuzzy sets to model assessors opinions in a decision making situation aiming to overcome unreliable opinions. Wu [49] uses fuzzy C-means to analyze English teachers' data in order to promote their evaluation ability and accuracy. Similarly Lubis et al. [66] used the same algorithm to measure learners satisfaction aiming to predict course completion of future students. Ospina-Delgado and Zorio-Grima [67] showed thru a fuzzy approach that the low intensiveness level in MOOCs is due to the absence of prestigious faculties.

Several methods have chosen fuzzy numbers to model opinions [68–71]. A fuzzy number (FN) $\tilde{A}$ [72] is a fuzzy set defined by its membership function $\mu_{\tilde{A}} : \mathbb{R} \to [0,1]$. We restrict ourselves to trapezoidal fuzzy numbers (TrFN) given by 4-tuples $\tilde{A}(a^1, a^2, a^3, a^4)$ where $a^1 \leqslant a^2 \leqslant a^3 \leqslant a^4$ and represented by:

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x - a^1}{a^2 - a^1} = \mu_{L_{\tilde{A}}}(x) & if\ a^1 \leqslant x \leqslant a^2 \\ 1 & if\ a^2 \leqslant x \leqslant a^3 \\ \dfrac{x - a^4}{a^3 - a^4} = \mu_{R_{\tilde{A}}}(x) & if\ a^3 \leqslant x \leqslant a^4 \\ 0 & else. \end{cases}$$

Considering two TrFNs $\tilde{A}(a^1, a^2, a^3, a^4)$ and $\tilde{B}(b^1, b^2, b^3, b^4)$ the fuzzy inverse (Eq. 1), fuzzy addition (Eq. 2), fuzzy multiplication (Eq. 3), and fuzzy division (Eq. 4) are defined as follows:

$$1/\tilde{B} = (1/b^4, 1/b^3, 1/b^2, 1/b^1) \quad (1)$$

$$\tilde{A} \oplus \tilde{B} = (a^1 + b^1, a^2 + b^2, a^3 + b^3, a^4 + b^4) \quad (2)$$

$$\tilde{A} \otimes \tilde{B} = (a^1 * b^1, a^2 * b^2, a^3 * b^3, a^4 * b^4) \quad (3)$$

$$\tilde{A} \oslash \tilde{B} = (a^1/b^4, a^2/b^3, a^3/b^2, a^4/b^1) \quad (4)$$

In the sequel we focus on enhancing validity and reliability of peer assessments.

3.1 Improving reliability

Reliability [61] can be driven from notes spread, intuitively if an evaluated work is assessed in the same time as very good and very bad in the same time, we can conclude automatically that the reviews are inconsistent with each other's.

Lee [70] proposed to solve the following problem in order to attribute adequate weights to coherent opinions $\tilde{R}_i(r_i^1, r_i^2, r_i^3, r_i^4)$ to achieve consensus $\tilde{R}(r^1, r^2, r^3, r^4)$:

$$\min_{M \times IR^4} \sum_{i=1}^{n} w_i^m * \left(c - S(\tilde{R}_i, \tilde{R})\right), \quad (5)$$

where, $M = \left\{ \begin{matrix} W = (w_1, w_2, \dots, w_n), w_i \geq 0, \\ \sum_{i=1}^n w_i = 1, \end{matrix} \right\}$

m is a positive integer $m > 1$, n number of decision makers, $S(\tilde{R}_i, \tilde{R})$ the similarity between the i^{th} decision and the consensus [69], c is a real number $c > 1$.

3.2 Improving validity

Validity [61], can be measured as the correlation between students' assessments and teacher's assessments. We proposed a modified version of the problem (Eq. 1) to include correlations e_i between the teacher and the i^{th} student in the process with the same constraints:

$$\min_{M \times IR^4} \sum_{i=1}^{n} w_i^m * \left(c - e_i * S(\tilde{R}_i, \tilde{R})\right), \quad (6)$$

While some successful test were realized on relatively small data [69]. Simulations are to be practiced on real MOOCs context, involving thousands of participants. However, it may be noted that even in MOOCs' situations, a relatively small number of judges assesses each work.

The problem (Eq. 6) can be resolved by the following algorithm:

Step 1: set the correlations/similarities between the teachers' and the i^{th} students' fuzzy evaluations such that $0 \leq e_i \leq 1$, the correlation/similarities are preferably normalized such that $\sum_{i=1}^n e_i = 1$.

Step 2: each DM expresses his opinion by a trapezoidal fuzzy number $\tilde{R}_i(r_i^1, r_i^2, r_i^3, r_i^4)$

Step 3: fix the initial weights $W^{(0)}\left(w_1^{(0)}, \dots, w_n^{(0)}\right)$ verifying $0 \leq w_i^{(0)} \leq 1$ and $\sum_{i=1}^n w_i = 1$. The iterations will be marked by $l = 0, 1, \dots$

Step 4: compute

$$\tilde{R}^{(l+1)} = \frac{\sum_{i=1}^n e_i * {w_i^{(l)}}^m \otimes \tilde{R}_i}{\sum_{i=1}^n e_i * {w_i^{(l)}}^m}$$

Step 5: compute

$$w_i^{(l+1)} = \frac{\left(1/\left(c - e_i * S(\tilde{R}_i, \tilde{R}^{(l+1)})\right)\right)^{1/(m-1)}}{\sum_{i=1}^n \left(1/\left(c - e_i * S(\tilde{R}_i, \tilde{R}^{(l+1)})\right)\right)^{1/(m-1)}}$$

Step 6: if $\|W^{(l+1)} - W^{(l)}\| \leq \varepsilon$ stop, else set $l = l + 1$ and go to step 4.

4 Illustrative examples

We adapt the example provided in [73] concerning peer evaluation. In this example, the student #A is evaluated by three participants (#B, #C and #D) according to 7 criteria of evaluation.

Table 1: Linguistic variable for each assessment

Linguistic grade	Abbreviation	Membership function
Poor	P	(0, 0, 1.5, 3.5)
Below average	BA	(0.5, 2.5, 3.5, 5.5)
Average	A	(2.5, 4.5, 5.5, 7.5)
Above average	AA	(4.5, 6.5, 7.5, 9.5)
Excellent	E	(6.5, 8.5, 10, 10)

4.1 Example 1: Improving reliability

In this stage, we suppose that all participant have the same weight. Hence, the difference will occur in order to improve reliability only.

Table 2: An example of peer assessment evaluation (reliability)

Evaluation criteria	Evaluators			Results
	#B	#C	#D	
Participated in group meetings	A A	E	E	(5.91, 7.91, 9.27, 9.85)
Communicated constructively to discussion	E	E	E	(6.5, 8.5, 10, 10)
Generally was	A	A	A	(4.5, 6.5, 7.5, 9.5)

cooperative in group activities	A	A	A	
Contributed to good problem-solving skills	AA	AA	A	(3.89, 5.89, 6.89, 8.89)
Contributed useful ideas	E	E	A	(5.55, 7.55, 8.93, 9.40)
Demonstrated good interest to task given	AA	AA	E	(5.09, 7.09, 8.23, 9.65)
Prepared drafts of report in good quality	E	E	AA	(5.91, 7.91, 9.27, 9.85)

The aggregated results are clearly attracted by coherent opinions, tacking the first and the last criteria as examples, the similarity between the aggregated result and the coherent opinions, E is more important than with the incoherent one AA.

4.2 Example 2: Improving validity

Now, we suppose that the participant #B is not an ordinary student but a teacher, hence, his opinion, and the closer opinions are considered more trustworthy. The aggregated results are presented in (Table 3):

Table 3: An example of peer assessment evaluation (validity)

Evaluation criteria	Evaluators			Results
	#B	#C	#D	
Participated in group meetings	AA	E	E	(5.75, 7.75, 9.06, 9.81)
Communicated constructively to discussion	E	E	E	(6.5, 8.5, 10, 10)
Generally was cooperative in group activities	AA	AA	AA	(4.5, 6.5, 7.5, 9.5)
Contributed to good problem-solving skills	AA	AA	A	(3.9, 5.9, 6.9, 8.9)
Contributed useful ideas	E	E	A	(5.58, 7.58, 8.97, 9.43)
Demonstrated good interest to task given	AA	AA	E	(5.07, 7.07, 8.21, 9.64)
Prepared drafts of report in good quality	E	E	AA	(5.93, 7.93, 9.29, 9.86)

The aggregated results are clearly closer to the teacher opinion, than in the previous experiment (Table 2).

5 CONCLUSION

Here we proposed a methodology to improve peer reviews validity and reliability through a programming approach. The opinions that were represented as fuzzy numbers, were aggregated in first place in order to promote coherent opinions and hence reliability is achieved. In second place correlation between the teacher and students were introduced permitting verifying validity.

In this work, assessors are supposed to be honest. Hence, we restricted ourselves to validity and reliability. In future works, we can consider other aspects such as collusions.

This work can be improved using different combination of correlation measures and decision making situations in order to target the best fitting correlations measure.

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