An Appraisal of a Collaboration-Metric Model based on Text Discourse

Author 1[1], Author 2[1,2], and Author 3[1]

[1]affiliation 1, [2]affiliation 2
email

Abstract. This paper presents a more in depth analysis based on discourse of the collaboration-metric model, *Word-Count/Gini-coefficient measure of symmetry* (WC/GCMS) which was introduced in [3]. We discuss the validity of the model as regards to how well it represents what happens in the groups' discourse content. We discuss the application and implication of WC/GCMS based on the goal to incorporate collaborative learning and its cognitive advantages to E-Learning environments.

Keywords: group discourse · online group · E-learning · collaboration-metrics

1 Introduction and Related Work

Online learning provides access to education for millions of learners through many environments offered by Universities and other organizations world wide , e.g. the Mass Open Online Courses. This motivates Computer Supported Collaborative Learning (CSCL) research towards leveraging the cognitive advantages of collaboration [4,15,23,25,31] for online learning, as it is preeminent in *traditional classroom* settings.

Online collaboration however has two major concerns: (i) *media richness*- the degree to which a virtual medium conveys the immediacy of face-to-face (F2F) conversation [27] and (ii) *social presence*- a communication that foster immediate interaction/feedback and permit people to communicate with multiple senses e.g. verbal and visual clues [27]. Media richness and online social presence are inter-dependent; the *richer* a media, the more social presence it conveys during online collaboration. For example in teleconferencing that coveys both the verbal and real-time image of collaborators compared to email exchange or other text-based conversation media. However, implementing robust media that conveys both verbal and visual clues for online programs comes with *costs* and *complexity* of deployment, which may inhibit the integration of group learning. Also, a group media enabled with verbal and visual interaction is most times *synchronous*; this eludes the *time flexibility* to participate, to think, and to search for extra information, to contribute in a group discussion, which comes with online collaboration e.g. in *asynchronous text-based media* [10,26,24]. Text-based group media is *cost efficient* and prospectively *effective* for online collaborative learning; Wever et al. [10] posit that, text-based discussion makes individual contributions more explicit and provide a better reflection of the process of collaboration for both researchers and instructors. It is a good data source to evaluate both collaboration and individual participation within group [17,22].

Online learners who interact via a text-based environment strive to maximize the social presence in the media [27]; a comparative study between *text-based* & *F2F* verbal discourse attests to similarities in both, despite a lack of facial expressions and gestures in the former [6]. Features such as *frequency of agreement or disagreement*, *use of negative affect terms* and *frequency of punctuation use* in text contributions reveal emotions of discussants, which is similar to facial expressions and gestures in F2F verbal discussions [13].

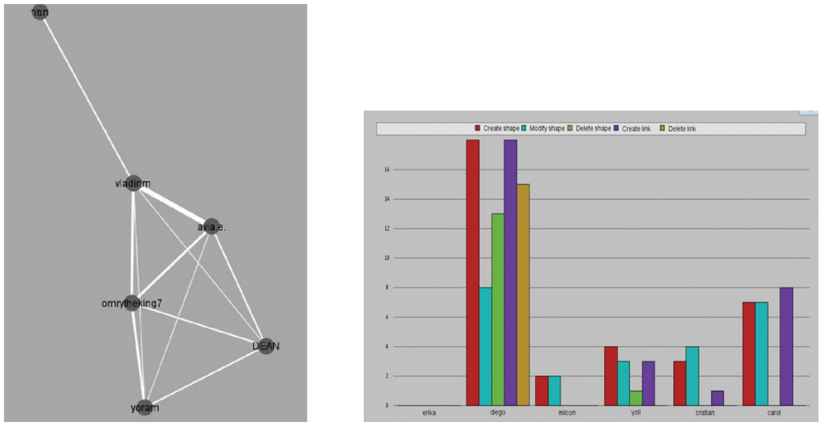
Online discussions provide evidence of collaboration as seen in *F2F*, although it has different representations in both; text or verbal information containing the same content will provide the same emotional or cognitive effect although processed differently [9]. Soller [30] corroborated this position stating that learners pose the natural inclination to adapt and maximize social presence when they use text-based media to interact; she however suggested that CSCL research needs to design a new adaptive method to support interaction in this environment.

1.1 Measure of Collaboration with Text Discourse

The instructors' view of collaboration via textual interaction had depended on a review of the transcripts of the groups' discourse [11]; analysis about how well groups have collaborated is possible only after the JPS process has ended and any feedback from such analysis is useful to moderate future group work. In order to accord online groups the kind of real-time support obtainable in a *F2F groups*, we require a real-time approach to view what goes on during online JPS.

Schwarz & Asterhan [28] explored this objective and presented a real-time view of group interaction using the social network of the connections between the activities within the group (see Fig. 1 a); the measure of participation by members was visualized with a bar charts, each bar representing different variables of activities involved in the task, for each group member (see Fig. 1 b).

Our model contributes to existing knowledge by providing a *simpler*, *scaleable* and *generically adaptable* computational mechanism that inform the level of collaboration during online JPS; applicable in real-time. In the following sections, we assess submissions from existing work about indicators and metrics of collaboration, the idea from these studies is aggregated and extrapolated for text-based online interaction, we present the rationale and mathematical relation that inform WC/GCMS model [3]. Finally we discuss the method we used to validate this model by triangulating qualitative assessment of the groups' discourse transcript, with the output of WC/GCMS model, we conclude with a discussion on the implications of the model as regards design framework for sustainable and effective online group learning environment.



(a) Group collaboration measure with Social network

(b) Individual group members' activities

Fig. 1: E-moderation of online group collaboration, Schwarz & Asterhan [28]

1.2 Indicators and Metrics of Collaboration within Groups

Much work has been done to identify indicators of collaboration during group JPS, more of these studies explored F2F or co-located gorups. For example, Martinez et al [18] mined the frequent sequential pattern of the log trace of groups' JPS activities around a table-top application to categorize groups into *high achieving* and *low achieving*. In a similar study, Martinez et al [19] proposed an approach to automatically distinguish between groups that engaged in a *collaborative* or *non-collaborative* activity during JPS.

Meier et al. [21] presented a rating scheme to quantify collaboration, Cukurova et al. [8] explored how *group synchrony* and *individual accountability*, *equality* and *intra-individual variability* informs good collaboration. The consensus found in these existing studies as regards to indicators of collaboration during JPS are: (i) ***Symmetry of contribution*** (ii) ***Volume of contribution*** (iii) ***Connectivity/links between contributions of different group members*** and (iv) ***the quality of contributions with respect to context of JPS***. In the next section, we will discuss how this informed the "Word-count/Gini-coefficient measure of symmetry (WC/GCMS)" collaboration metric model .

2 Word-count/gini-coefficient measure of symmetry

The components of the *Word-count/gini-coefficient measure of symmetry (WC/GCMS)* presented in [3] are given by:

WC/GCMS metric of collaboration is given by:

$$G_{cl} = \frac{G(w_{ct})}{G_c} \tag{1}$$

$G(w_{ct})$: represents the volume of activities/texts that the group generate during JPS; assuming that this volume informs the quality of the JPS process [20].
G_c: represents the symmetry of the activities within the group, and is based on the gini-coefficient measure of symmetry. It ranges from 0-1; 0 being perfect symmetry and 1 asymmetry. Assuming that symmetry of JPS activities is an indication of group collaboration, the numerical value of the G_c is inversely proportional to the group collaboration level i.e. $collaboration \propto \frac{1}{G_c}$.
G_{cl} : measures the collaboration within a group.

Volume of group activities: A member i within a group contributes textual statements $\overrightarrow{S}_1, \overrightarrow{S}_2, ..., \overrightarrow{S}_m$, at time intervals during JPS. All text contributions by member i is a collection of statements, $\overrightarrow{k}_i$. The measure of contribution during JPS by member i, is thus given by equation 2.

$$w^i_{ct} = \sum_{j=1}^{m} \mid \overrightarrow{S_j} \mid, where\, m = \mid \overrightarrow{k}_i \mid \tag{2}$$

Hence, within a group of 4 members, we have contributions $w^1_{ct}, w^2_{ct}, w^3_{ct}, w^4_{ct}$. Considering that a non-collaborating member may contribute very little and an extrovert may provide an excessively high text contribution, we represent the group activity volume measure, $G(w_{ct})$ with the median w_{ct} in the group:

$$G(w_{ct}) = median(w^1_{ct}, w^2_{ct}, ..., w^n_{ct}) \tag{3}$$

Symmetry of activity within group This is based on the gini-coefficient measure of symmetry adapted from [19]. Firstly, we compute the mean number of contributions by group members (equation 4a), then the symmetry of contributions within the group (equation 4b):

$$k_{mean} = \frac{1}{n} \sum_{i=1}^{n} \mid k_i \mid \tag{4a}$$

$$G_c = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |k_i - k_j|}{2n^2 k_{mean}} \tag{4b}$$

Next, we describe the output of WC/GCMS with data from 5 groups. The study procedure, a brief discussion about the model and findings was presented in [3]. Here we provide an expanded and more exploratory discussion on the validity of WC/GCMS for quantifying collaboration with text-based discourse.

3 Text-based discourse data source

The text-based discourse of 5 groups was collected in a study by Adeniran et al [3]. The groups were formed from a convenience sample of undergraduate/postgraduate students. Each group had 4 members: (Group 1) 3 male, 1 female, all aged 18-25; (Group 2) 3 male, 1 non-disclosed; all 18-25; (Group 3) 2 male, 2 female; all 18-25; (Group 4) 4 male, all 26-35; (Group 5) 4 male, 3 26-35, 1 36-45. In the study, the groups solved a joint task, the task [1], is an *open ended problem without clear cut answers* as recommended by [7] for group work. JPS was via a text-based chat-room designed for the study [3]. Discourse is collected in a database; contributions are *time-stamped*, uniquely but anonymously identified with the contributor. This data serves as input for our WC/GCMS model, which tells how well the groups have collaborated relatively.

3.1 Visualization with WC/GCMS metric

Figure 2a shows the relative measure of collaboration between groups based on total discourse, Figure 3 simulates a real-time view of this measure during JPS. Figures 2 and 3 can inform a remote teacher about which group is collaborating less well. We did not define a measure for a *collaborative* or *non-collaborative* group; WC/GCMS depends on the comparison between the groups to determine which group needs attention most, at a given time during JPS.

The measure of individuals' participation within the group (shown in Figure 2 b) provides a hint about non-participating members; for example, **M3** in group 1 or **M4** in group 4. The components of WC/GCMS i.e. $G(w_{ct})$ & G_c, are viewed in real-time as shown in Figure 4; this provides information about the groups' JPS process as discussed below. Figure 4a visualizes $G(w_{ct})$; we can observer a higher *ripple* in the line representing Groups 3 & 5, showing that the symmetry of contribution within the group changes more rapidly during JPS. It is a sign of high frequency of contribution within the groups which can be hypothesized as an indication of members' interest in the discussion or a relatively higher knowledge about the task i.e. the members have more to contribute. On the contrary, the lines representing Groups 2 & 1 are smoother and the Group 4 line the smoothest, indicating that the participation rate in these groups is lower.

From Figure 4 b, which visualizes G_c, we can observe that the volume of text contribution in Group 3 & 5 is higher and increases steadily during their JPS discussion, corroborating that if the contribution rate is higher the contribution volume will be higher. This also confirms the position of Martinez [18], that a high verbal activity is an indication of collaboration; in our context: *high textual contribution indicates collaboration in a text-based discourse.*

4 Validation: WC/GCMS output versus Qualitative Assessment of Discourse

To validate the WC/GCMS's visualizations, we use the groups' discourse transcripts to make a comparative analysis with the inferences from the visualization.

Collaborative activity-states of contributions: Contributions that aid collaboration were conjectured to assume one of the following activity-states: *task coordination*, *acknowledgement*, *request*, *inform*, *argue* and *motivate* [2,29]. We assess groups' discourse to determine how much evidence of these collaborative activity-states exist therein and compare these between the groups. Firstly, at

(a) Group measure (b) Individual activity measure within group

Fig. 2: Final collaboration measure between groups based on discourse content (a), and individual participation measure (of members M1-M4) within groups based on the number and word count of contributions (b).

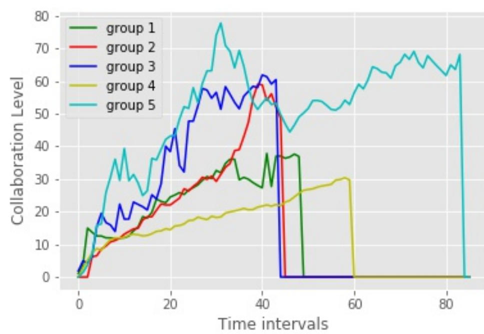
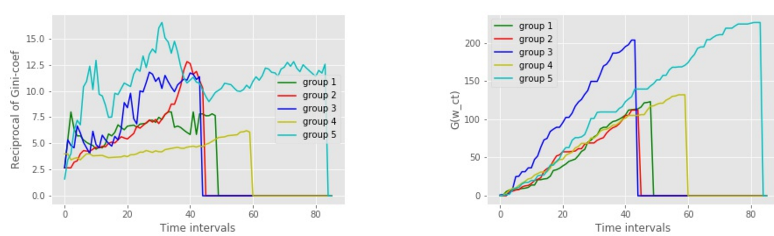


Fig. 3: Simulated Real-time view of collaboration level



(a) $1/G_c$ measure between groups (b) $G(w_{ct})$ measure between groups

Fig. 4: Components of WC/GCMS model

the group discourse start, there is evidence of initial coordination within Groups 3 and 5, indicating an interest and enthusiasm to participate; contrary to our observation in the discourse of Groups 1, 2, & 4. Participants in the latter groups did not make any effort to familiarize with the task nor with group members; they went ahead to give suggested solutions. See Table 1.

Secondly, there is evidence of *informed argument*, *planning* and *suggested strategies* to solve the joint task in the Groups 3 & 5 discourse; as opposed to that of Groups 1,2, & 4, where the contributions are mostly erroneous *suggested solutions* with blind acceptance and acknowledgement. Most contributions from Groups 1,2, & 4 is similar to what Webb [32] refers to as "giving and receiving non-elaborated help", i.e. unexplained solutions to the JPS task. Such contributions during group learning provide no cognitive benefit to the giver of the information nor to other members. The extract from Group 5 discourse particularly contains cognitive elaboration, which is posited to be an evidence of collaboration [32]. The relative level of collaboration between groups shown by WC/GCMS (as shown in Figures 2a and 3) is thus justified.

Table 1: Evidence of ***coordination***[1]

Group 3:

```
Beowulf: Good Morning everybody
Epigha: What item do we think should have the highest ranking of 1?
        I suggest oxygen
Epigha: Any other suggestion?
Anonymous1: I think safety is most important, so life raft is my
            suggestion
Beowulf: My ratings were based on a few things know about the moon.
        // First: there is no atmosphere
        // Second: It is very cold
        // Third: there is no magnetic field
Epigha: If there is no atmosphere, how can you breathe without oxygen?
        I think you need to breathe before considering safety
```

Group 1:

```
Lucas : Hello...
charis : how are we starting the ranking
charis : ..
Ranco : Watson
Lucas : Guess we are waiting for one more participant
Ranco : Can we start pls?
Ranco : Most important (1) oxygen
Lucas : "I think we canCharis, still online?"
Lucas : I will go for oxygen as the most important (1).
Ranco : Opinion pls?
Ranco : Hello....
Lucas : I think water should be 2
```

Group 2:

```
olu : which do you think should be first fellas?
Carbon : Since we dont knw when d 4th member will be available
smith : I think oxygen
Carbon : Stellar mapYeahNo 1 item = oxygen
olu : what about first aid?
olu : I think I agree with map i.e directionmap,
          compass, first aid
smith : Oxygen should be the most important
smith : Oxygen is needed for survival in space
Carbon : First aid should be later
```

Group 5:

```
sir D  : Hello
Cg  : Hello
Cg  : I have just been writing notes on all the items
      whilst waiting.
Mide   : Hi Cg
Cg  : I just submitted my thoughts on the items and the
      system deleted the message.
Cg  : Hi
Ku : hi everyone
```

Group 4:

```
smart : Oya, so what is your view? Swiftly
Swift : Obviously, first place important thing is oxygen
Swift : Then water, followed by food
Swift : What do you think?
smart : Yes, oxygen... Correct
smart : Yes.. In that order
smart : Without it
smart : All those in order,
Swift : So, what do you think should be the next?
```

Non-participating group members: Logically, the rate of participation by an individual group member is directly proportional to the collaboration level within the group. The discourse transcript shows that member "charis" in Group 3 & "unknown" in group 4 did not participate relatively well within their respective groups. This explains the low bar for **M3** in Group 2 and **M4** in Group 4 as shown in 2 and further validates WC/GCMS output.

Quality of contribution and knowledge about task: Assessment of discourse of Groups 5 & 2, shows evidence of information sharing, of new knowledge, suggestions based on logical reasoning about the task. Their discussion conveyed knowledge of context (the moon environment) and transfer of knowledge (see Table 2). This kind of elaborated discussion indicates *participants' socializing during small group discussion* as posited by [14]. On the contrary, the discourse of Groups 1,2, & 3 lacks such *knowledge-based* interaction; this

Table 2: Evidence of ***Other collaborative activity-states***[2]

Group 3:

```
Beowulf : My ratings were based on a few things I know about the moon.
         // First: there is no atmosphere // Second: It is very cold
         // Third: there is no magnetic field
Epigha : If there is no atmosphere, how can you breathe without
         oxygen?
        I think you need to breathe before considering safety
cls603 : I rated Solar-powered FM receiver-transmitter 1st
         because the to communicate with their base
Epigha : Beowulf and cls603, what is your contribution?
Epigha : cls603, I think communication can come after survival
         and safety
Beowulf : I rated the oxygen tanks as the most important item,
          for breathing
Epigha : I give oxygen tank highest priority too
Epigha : Do we all agree with oxygen tank = 1
Beowulf : I agree with that
cls603 : Alright I agree with the oxygen
Anonymous1 : Oxygen OK
Epigha : We move to the next item then. what item is the second
         highest priority?
Beowulf : Water is a priority, but because the moon is cold, the
          heater is needed to make the water liquid rather than frozen.
```

Group 1:

```
Lucas : I think water should be 2
Ranco : Ok....same here...good
Lucas : "Ranco, Any suggestion for 3?"
Ranco : One case of dehydrated milk
Ranco : ???
Lucas : Hmmm....is that really important? Remember we have water already
Lucas : "With oxygen and water, i think the instruments to get them to
        their location should come next"
Ranco : "Ok, at what point do think we will need milk and food? Jst
        asking?"
Lucas : After the basic instruments
      : So the stellar map, United
```

Group 2:

```
smith : I think oxygen
Carbon : Stellar mapYeahNo 1 item = oxygen
olu : what about first aid?
olu : I think I agree with map i.e directionmap, compass, first aid
smith : Oxygen should be the most important
smith : Oxygen is needed for survival in space
Carbon : First aid should be later
olu : oxygen is as well important
Carbon : After all navigation tools has been pick
olu : you can fix oxygen without the first aid kit
smith : first aid is as well important
smith : but proactive measures should be taken before reactive measures
olu : 1. map2. compass3. oxygen
Carbon : Health first
olu : 4. first aid
Carbon : I think first aid and oxygen shoyld be first
olu : any other opinion for the first four rating
```

Group 5:

```
Cg : The parachute is useful in that it is a large piece of
     material. But I do not think that high
sir D : no gravity
Cg : It can be used for things other than its intended use.
Cg : There is gravity but no atmosphere.
Mide : U WIL NEED PARACHUTE SINCE U ARE AIR, FOR LANDIND, SAFETY
Cg : Was the scenario that you had landed, or were away to land?
        Also there is no information about the parachute. How big is
        it?
Ku : I think we should first have clusters like A. survival
         B. Safety and C. Set Objective Then from this clusters we rank
         the items in each cluster. And naturally we solve the problem
Cg :  Is it not your objective to survive?
sir D :  yes it is
sir D : "and the scenario says "" mother ship on the lighted surface of
        the moon """
Cg : "I think we need to start with either the number 1 or the number 15
      and say ""OK, which item would  leave behind if we had to"". That
      is 15. Then do it again, again etc."
```

Group 4:

```
smart : Yes, oxygen... Correct
smart : Yes.. In that order
smart : Without it
smart : All those in order,
Swift : So, what do you think should be the next?
smart : A feel a magnetic compass
smart : Cos they would have to knw
smart : Where they wanna go
Swift : Yeahh...I agree
smart : Then the receiver-transmitter To keep contact
smart : What do u think?
Swift : The stellar map should come before the compass
Swift : Then the receiver-transmitter should come after the compass
smart : Oh
smart : That true
smart : What about the heating unit
smart : I feel the moon is kinda cold u know
smart : For a 200miles journey
Swift : Hmmm...yeah
```

inhibits socialization within the groups [14]. In line with the *Vygotskian perspective* as mentioned in [32] that collaboration provides cognitive benefits when "a more expert member helps less-expert ones". Studies have also shown that there is a *knowledge level threshold* for a task that can foster optimum collaboration within groups; below it, a group will not attempt a solution at all or suggest unexplained erroneous solutions which hinders collaboration and cognition [**?**].

5 Conclusions

The major contributions of this paper are: first, based on literature, we argue that a text-based media is efficient and can be optimized to maximize social presence within an online group [6,10,26,24,27]. Second, existing studies proposed measures of collaboration that use the text discourse transcript, providing an analysis after the discourse has been completed [12,5,16], whilst *WC/GCMS* is intended to be used in a real-time group monitoring dashboard for a remote teacher.

Third, we present an explicit comparative analysis of the *WC/GCMS* metric output with an assessment of the groups' discourse, to validate the model's sensitivity as regards quantifying text-based group collaboration. We posit that WC/GCMS can provide simple, easily interpret-able graphical outputs, upgradeable (to capture verbal and visual clues when using richer interaction media) and generic (can be extrapolated to the collaboration context).

Whilst the indicators of collaboration exceed the characteristics of the text discourse content used in this paper, WC/GCMS is sensitive enough to serve as a proxy-effective metric of collaboration and participation within online groups. We plan to run a larger scale study to further investigate the indicators, factors and models presented. We will also investigate the use of our metrics and visualizations to provide real-time feedback to learners to scaffold collaboration, and measure both quantitatively and qualitatively the effect of such feedback on JPS. We further aim to develop algorithms for a computer agent (taking our models as input) to stimulate participation and consequently scaffold collaboration.

References

1. Moon exercise. `humber.ca/centreforteachingandlearning/assets/files/pdfs/MoonExercise.pdf`.
2. A. Adeniran. Investigating feedback support to enhance collaboration within groups in computer supported collaborative learning. In *AIED Conference*, pages 487–492. Springer, 2018.
3. A. Adeniran, J. Mathoff, and N. Beacham. Model-based characterisation of discourse content: An evaluation of collaboration within online groups. AIED, 2019.
4. E. Alfonseca, R. M. Carro, E. Martín, A. Ortigosa, and P. Paredes. The impact of learning styles on student grouping for collaborative learning: a case study. *User Modeling and User-Adapted Interaction*, 16(3):377–401, 2006.
5. M. A. Andresen. Asynchronous discussion forums: success factors, outcomes, assessments, and limitations. *J. Educ. Techn. & Society*, 12(1):249–257, 2009.
6. R. Bromme, F. W. Hesse, and H. Spada. *Barriers and biases in computer-mediated knowledge communication: and how they may be overcome*. Springer, 2006.
7. E. G. Cohen, C. M. Brody, and M. Sapon-Shevin. *Teaching cooperative learning: The challenge for teacher education*. Suny Press, 2004.
8. M. Cukurova, R. Luckin, M. Mavrikis, and E. Millán. Machine and human observable differences in groups collaborative problem-solving behaviours. In *European Conference on Technology Enhanced Learning*, pages 17–29. Springer, 2017.
9. D. D. Curtis and M. J. Lawson. Exploring collaborative online learning. *Journal of Asynchronous learning networks*, 5(1):21–34, 2001.
10. B. De Wever, T. Schellens, M. Valcke, and H. Van Keer. Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & education*, 46(1):6–28, 2006.
11. L. P. Dringus and T. Ellis. Using data mining as a strategy for assessing asynchronous discussion forums. *Computers & Education*, 45(1):141–160, 2005.
12. A. Driscoll, K. Jicha, A. N. Hunt, L. Tichavsky, and G. Thompson. Can online courses deliver in-class results? a comparison of student performance and satisfaction in an online versus a face-to-face introductory sociology course. *Teaching Sociology*, 40(4):312–331, 2012.

13. J. T. Hancock, C. Landrigan, and C. Silver. Expressing emotion in text-based communication. In *SIGCHI conf. on Human factors in comp. Sys.* ACM, 2007.
14. M.-c. Ho. Academic discourse socialization through small-group discussions. *System*, 39(4):437–450, 2011.
15. S. Liu, M. Joy, and N. Griffiths. Incorporating learning styles in a computer-supported collaborative learning model. 2008.
16. M. Loncar, N. E. Barrett, and G.-Z. Liu. Towards the refinement of forum and asynchronous online discussion in educational contexts worldwide: Trends and investigative approaches within a dominant research paradigm. *Computers & Education*, 73:93–110, 2014.
17. J. Macdonald. Assessing online collaborative learning: process and product. *Computers & Education*, 40(4):377–391, 2003.
18. R. M. Maldonado, K. Yacef, J. Kay, A. Kharrufa, and A. Al-Qaraghuli. Analysing frequent sequential patterns of collaborative learning activity around an interactive tabletop. In *Educational Data Mining 2011*, 2010.
19. R. Martinez, J. Wallace, J. Kay, and K. Yacef. Modelling and identifying collaborative situations in a collocated multi-display groupware setting. In *Artificial Intelligence in Education*, pages 196–204. Springer, 2011.
20. R. Martinez-Maldonado, Y. Dimitriadis, A. Martinez-Monés, J. Kay, and K. Yacef. Capturing and analyzing verbal and physical collaborative learning interactions at an enriched interactive tabletop. *I.J of CSCL*, 8(4):455–485, 2013.
21. A. Meier, H. Spada, and N. Rummel. A rating scheme for assessing the quality of computer-supported collaboration processes. *I.J. of CSCL*, 2(1):63–86, 2007.
22. K. A. Meyer. Evaluating online discussions: Four different frames of analysis. *Journal of Asynchronous Learning Networks*, 8(2):101–114, 2004.
23. D. R. Newman, B. Webb, and C. Cochrane. A content analysis method to measure critical thinking in face-to-face and computer supported group learning. *Interpersonal Computing and Technology*, 3(2):56–77, 1995.
24. J. Pena-Shaff and C. Nicholls. Analyzing student interactions and meaning construction in computer bulletin board discussions. *Comp. & Educ.*, 42(3):243–265, 2004.
25. J. R. Savery and T. M. Duffy. Problem based learning: An instructional model and its constructivist framework. *Educational technology*, 35(5):31–38, 1995.
26. T. Schellens and M. Valcke. Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing? *Computers in Human behavior*, 21(6):957–975, 2005.
27. S. Schneider, J. Kerwin, J. Frechtling, and B. Vivari. Characteristics of the discussion in online and face-to-face focus groups. *Soc.Sc.Comp.Rev.*, 20:31–42, 2002.
28. B. B. Schwarz and C. S. Asterhan. E-moderation of synchronous discussions in educational settings: A nascent practice. *J. of the Learn. Sc.*, 20(3):395–442, 2011.
29. A. Soller. Supporting social interaction in an intelligent collaborative learning system. *Int. JAIED*, 12:40–62, 2001.
30. A. Soller, A. Martínez, P. Jermann, and M. Muehlenbrock. From mirroring to guiding: A review of state of the art technology for supporting collaborative learning. *Int. JAIED*, 15(4):261–290, 2005.
31. H. Suh and S. Lee. Collaborative learning agent for promoting group interaction. *ETRI journal*, 28(4):461–474, 2006.
32. N. M. Webb. The teacher's role in promoting collaborative dialogue in the classroom. *British Journal of Educational Psychology*, 79(1):1–28, 2009.