Development of Critical Thinking Disposition Using an Online Discussion Board During a Fully Online Course

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Abstract: Online discussion is a key learning activity for developing literacy of critical thinking disposition (CTD). The effectiveness and activities of online discussion during a blended learning setting have been analysed. The aim of this paper is to extract student's characteristics during online discussions in a fully online course in order to invite more participants to join and to encourage discussion. The differences in student's characteristics and learning performance between online discussants and non-participants were statistically analysed. Key characteristics were extracted and discussed using regression analysis. Also, causal relationship of the development of literacy of CTD were extracted and the learning progress of online discussants was examined.

Keywords: critical thinking, online discussion, student's characteristics, science and technology literacy, learning style

1. Introduction

The development of the critical thinking disposition (CTD) is essential when it comes to judging which information is accurate and reliable, and to having the ability to understand what the actual situation really is in any given instance. These skills and an appreciation of science and technology are necessary in modern society in order to be able to discern what is evidence and what is mis-informatation. (Rychen and Salganik, 2003; Nakayama et al. 2020). In particular, CTD ability and information processing skills are necessity in order to evaluate news about natural disasters and man-made calamities when speculative, biased or misleading tactics are used by the media. The development of these abilities is often necessary for the making of policies which can mitigate natural disasters. However, an appropriate educational methodology has not yet been established. As a study option, discussion activity may help students to be aware of the need to think critically in a blended learning course (Nakayama et al., 2019, 2018). The number of participants is limited by the opportunity for face to face discussion. As another option, bulletin boards or online communication tools may help to develop CTD ability (Kusumi and Tanaka, 2008; Leh et al., 2012; Ekahitanond, 2013; Trehan et al., 2017; Nakayama et al., 2019).

As essay writing ability may also contribute to CTD development, the authors have been studying essay reviewing activities (Nakayama et al. 2009; Nakayama et al. 2020). This approach is possible even with a large scale face-to-face class at a university or an online learning environment (Nakayama et al., 2021). The function of the online communication facility has been provided, but the activation of online discussion is not easily accomplished. Recent circumstances allow only online instruction and no face-to-face sessions. Another problem that has been recognised is how to invite participants to become involved in online discussions.

In this paper, the authors review certain aspects of online discussion for CTD development using metrics of student's surveys in an online course. The following topics will be addressed:

- (1) Scores of student's characteristics for online discussants and non-participants were compared during a fully online course.
- (2) Discrimination analysis of online discussants was conducted using the student's initial characteristics.
- (3) Causal analysis of development of critical thinking disposition using student's characteristic was conducted in order to illustrate the process of formulating CTD and learning performance.

2. Method

The development of CTD was observed during a regularly scheduled fully online course at a Japanese university, and was organised in an on-demand style (Nakayama et al., 2021).

2.1 Learning settings

The course was entitled The Psychology of Natural Disaster Mitigation and Prevention, and consisted of 15 sessions. Learning performance of participants was evaluated using several activities, such as weekly confirmation tests and report assignments.

The course has been organised as a fully online since 2020. The lecturer recorded videos of his lectures in advance, and the video clips for each session were delivered using the LMS. Therefore, all participants joined the course flexibly as off-campus students, and there was no face-to-face lecture room instruction. All communications such as assignment submissions, online tests, essay report reviews and follow-up surveys were conducted using the LMS. The learning performance was evaluated using online tests such as short writing tests which asked about course session topics and practices.

During the course, 341 participants responded to some of the surveys, and the valid number of participants in the analysis which follows was 252 in the 2021 course year.

Online discussion boards were available during the course, and all participants could join the discussions. The lecturer monitored student's postings and intervened when necessary. The number of valid discussants was 42.

2.2 Survey metrics

The following inventories were surveyed regularly during the course in order to summarise the characteristics of participants. Most metrics were measured continuously, as in previous studies (Nakayama et al. 2018, 2019, 2020, 2021).

2.2.1 Personality (Big5)

Scores of participant's personalities were measured using a shortened version of the Big5 inventories, which consists of 10 question items (Kawamoto et al. 2015). The factors which were extracted were Extroversion (P1), Conscientiousness (P2), Neuroticism (P3), Openness (P4), and Agreeableness (P5). The factor scores of the Big5 use 7-point scales (1-7).

2.2.2 Critical thinking disposition (CTD)

Hirayama and Kusumi (2004) developed a Japanese inventory of behaviour exhibited during development of critical thinking. Four factors from the inventory were extracted: Awareness of logical thinking (CTD-1), Inquiry-mindedness (Inquisitiveness) (CTD-2), Objectiveness (Objectivity) (CTD-3), and Evidence-based judgement (CTD-4). These CTDs were scored using a 5-point scale (1-5). These metrics were surveyed twice during the course as the first and the second halves. The differential scores between two surveys are also used in the following analysis.

2.2.3 Information-processing Style (IPS)

Personal styles of information processing and judgement were measured using the Rational and Intuitive Information Processing Style Inventory (Naito et al. 2004). Two factor scores, such as Rationality (IPS-1) and Intuition (IPS-2), were calculated using this inventory. These were also scored using a 5-point scale (1-5).

2.2.4 Literacy of science and technology (LST)

Kawamoto et al (2013) developed an inventory of science and technology literacy which is based on a survey of scientific literacy. It consists of 10 questions, from which four factors were extracted from the answers: Life-centered (LST-1), Sciencephile (people who are interested in science and technology) (LST-2), Logic-oriented (LST-3), and Authoritarian (LST-4). The LSTs were scored using a 4-point scale (1-4). Four clusters of LSTs were also defined in order to compare behavioural attitudes toward Social science issues using the four dimensional factor scores (Kawamoto et al. 2013).

2.2.5 Additional participant evaluation metrics

Participant's performance was measured using test results from each session of the course. These were defined as “Overall assessment scores”. Additional “Review essay assessment” scores were extracted in order to evaluate CTD ability by applying the IRT technique (Linn, 1989) to rating scores of participant’s reviews of 13 peer’s essays (Nakayama et al., 2020, 2021).

The participant’s essay reports were evaluated by the course lecturer using a rubric which was presented to participants in advance for the fairness assessment. The targeted essay assignment was a task for a session.

3. Results

3.1 Characteristics of online discussants

In order to extract typical characteristics of online discussants, surveyed metrics are statistically compared between the two groups. The results are summarised in Table 1. Means and STDs of factor scores in the two groups are compared. Since some surveyed data is missing, the overall number of individuals is reduced.

Table 1: Comparison of factor scores between participants of online discussions and non participants

	Online Discussion (mean, STD)		
Factors	Joined(N=32)	No(N=173)	t value
Extroversion	**4.4(1.7)**	**3.8(1.5)**	**2.1(*p<0.05*)**
Conscientiousness	3.4(1.4)	3.2(1.3)	
Neuroticism	4.5(1.2)	4.5(1.3)	
Openness	4.2(1.3)	3.8(1.3)	
Agreeableness	2.7(1.0)	2.8(0.9)	
Awareness of logical thinking	2.9(0.7)	2.8(0.7)	
Inquiry-minded	**4.1(0.6)**	**3.9(0.6)**	**2.3(*p<0.05*)**
Objectiveness	3.8(0.6)	3.7(0.6)	
Evidence-based judgement	3.6(0.7)	3.6(0.7)	
Life-centered	3.8(0.9)	3.5(0.8)	
Sciencephile	3.7(1.0)	3.5(0.7)	
Logic-oriented	3.5(0.8)	3.3(0.7)	
Authoritarian	2.9(0.9)	3.0(0.7)	
Rationality	**3.6(0.6)**	**3.2(0.6)**	**3.9(*p<0.01*)**
Intuition	2.9(0.6)	3.0(0.6)	

The differences in means between the two groups are examined using a t-test. In the results, three factor scores are significantly different, such as "Extroversion" of personality, "Inquiry-mindedness" of CTDs, and "Rationality" of information processing style. All means for online discussants are significantly higher than the means for non-participants. Some student's characteristics may affect student's behaviour during online discussions.

The composite factor scores may influence participant's learning activity. In a more detailed analysis, the differences are compared carefully, with consideration given to individual factor score patterns by using propensity scores and propensity score matching techniques to reduce the effect of individual factors (Hoshino, T. and Okada, K., 2006). As the result, there are no variables which present significant difference between the two groups. This result shows that the student's overall characteristics promote online discussion. This factor will be reanalysed in the following sections.

3.2 Learning performance analysis

Since attitude toward learning, such as the characteristics of students did not explicitly affect online discussion activity, conventional learning performance was analysed, such as knowledge-based session test scores for “Overall assessment scores”, lecturer's assessment scores for individual essay reports, and “Review essay assessment” scores. The “Review essay assessment” scores are generated using an IRT based graded response model and patterns of individual rating scores for each of the 13 essay reports.

Results of simple analysis show that “Overall assessment scores” may be a common assessment index. The relationships between the three measures are summarised in scatter grams in Figure 1. Figure 1(a) shows the

relationship between overall assessment and essay performance, and Figure 1(b) shows the relationship between overall assessment and "Review essay assessment" scores. Both correlation coefficients are relatively small, but significant coefficients such as *r=0.22* and *r=0.16* show that student's performance may depend on knowledge-based performance.

The coefficients are compared in Table 2, using upward-oriented triangles for coefficients of non-participants and downward-oriented triangles for coefficients of online discussants. The effect of the small sample size may influence the coefficients for online discussants, as their performance is independent of each other. If the progress of CTD development is affected by this independence, online discussants may acquire the attitude of critical reviewers during the course. The effect of sample size should be considered carefully.

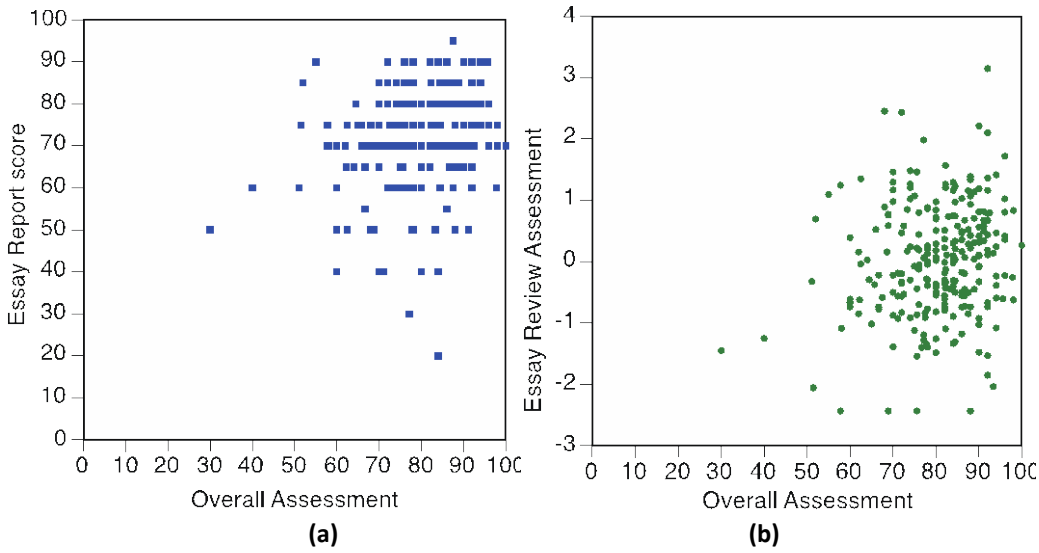

Figure 1: (a) Scattergram for overall assessment and essay report score (*r=0.22*); (b) Scattergram of overall assessments and essay review assessments (*r=0.16*)

Table 2: Correlation coefficient performance

	Tests	Report	Review rating
Tests		**0.17**	**0.21**
Report	*0.20*		*0.08*
Review rating	*0.13*	*-0.17*	
Non(N=212): Upper Angular, Joined(N=40): Lower Angular			

3.3 Features of online discussants

Once again, the features of online discussants are extracted using a logistic regression analysis which is a kind of discrimination procedure. In order to determine the features of individuals, analysis was conducted using a variable selection procedure.

In the results, 7 variables were selected as contributions of online discussants. They are summarised in Table 3. The selected variables are two personality scores, four CTD scores and the information processing style. The four selected CTD scores were surveyed at the beginning of the course. Therefore, all variables reflect student's initial attitudes. The positive weighted variables are Agreeableness and Objectiveness. These types of participants may have the potential to be online discussants. Also, other participant's characteristics may affect to join the online discussion. An appropriate procedure to invite their participation and contributions of participant's characteristic should be considered.

Table 3: Selected variables for detecting online discussants

Variables	Coefficient	SD Error	Pr>Chisq
Neuroticism	-0.29	0.21	0.16
Agreeableness	0.47	0.30	0.12
Awareness of logical thinking	-0.52	0.43	0.23

Variables	Coefficient	SD Error	Pr>Chisq
Inquiry-minded	-1.05	0.52	0.04
Objectiveness	1.17	0.45	0.01
Evidence-based judgement	-0.42	0.42	0.32
Rationality	-1.00	0.52	0.05

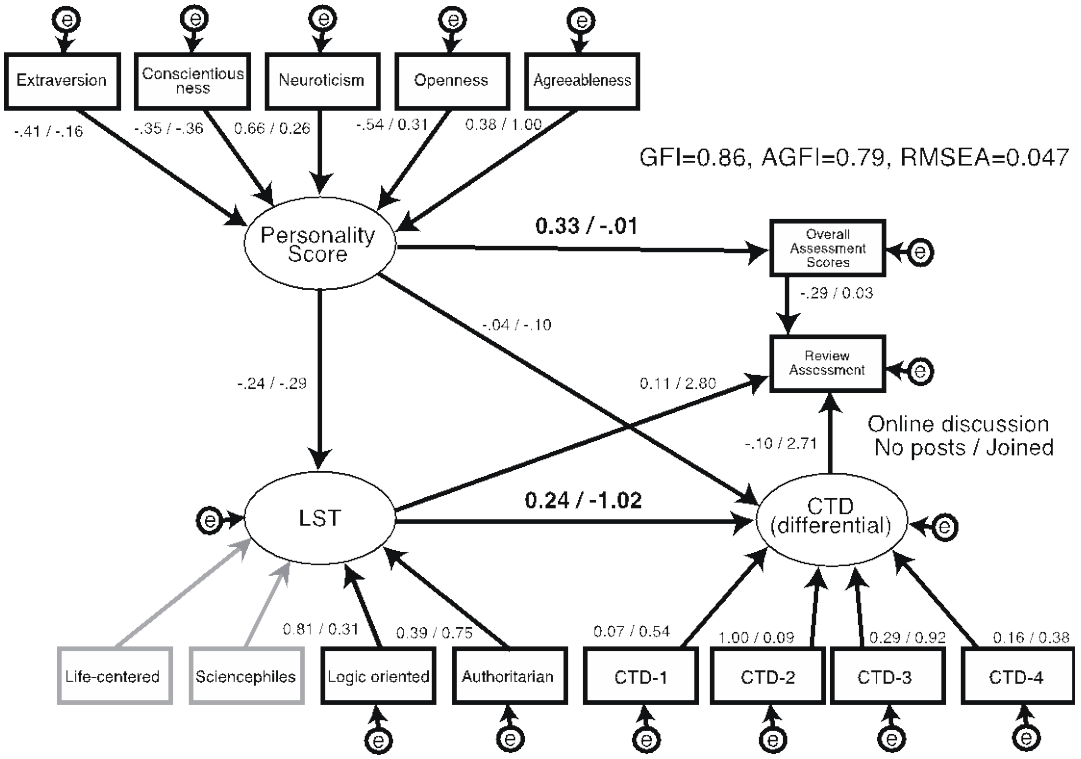

Figure 2: Causal relationship between student's characteristics (Personality and Literacy of Science and Technology) and development of critical thinking disposition for online discussants and non-participants

3.4 Causal relationship

The relationships between student's characteristics, CTD development and learning outcomes are compared using two online discussion groups, namely online discussants and non-participants. During the analysis, it may be possible to confirm whether those participating in online discussions are affected by CTD development.

In order to extract the relationships, a structural equation modelling technique was applied and the results evaluated using a causal relationship between them, as was done in the previous study (Nakayama et al. 2021).

The causal relationships were evaluated using indices of the fitness of the model (the GFI: Goodness of Fit index, AGFI: Adjusted GFI and RMSEA: Root Mean Square Error of Approximation) (Toyoda, 2007). Contributions of some factor scores were checked to optimise the model.

As a result, a possible causal path was extracted, as shown in Figure 2. The model was significant in regards to the evaluation indices (*GFI=0.86, AGFI=0.79, RMSEA=0.047*). The coefficients of path connections are compared between online discussants and non-participants. In a statistical test of coefficients, there are significant differences in "Personality Score" and "Overall Assessment Scores", and "LST" and "CTD (differential)". In both cases, the coefficients for non-online discussants are positive, and the coefficients for online discussants are negative. As mentioned in the above analysis, although online discussants have sufficient ability, their development during the class may be limited.

4. Summary and discussion

The purpose of this paper is to extract the differences in learning activities between participants and non-participants of online discussions in a fully online course. The survey consists of hierarchical analysis between two levels.

First, characteristics of course participants were compared between two groups using conventional metrics such as personality factors of Big-5, cognitive styles and literacy of science and technology (LST). The online discussants scored higher in factor scores for Extroversion of personality and Rationality of information processing style. The factor score for inquiry-mindedness of CTD for discussants is also significantly higher than for the non-participants. However, the use of another analytical approach did not find any significant differences in observed variables. The variables contributing to identification of online discussants were extracted, and consisted of the initial CTD factor scores, and some factor scores of personality and Rationality. The result suggests a factor pattern for identifying potential online discussants. The encouragement of the use of this procedure should be considered.

During the course, participation in session tests and the writing of essay reports were requested. Again, online discussants' scores are also significantly higher than those of others ($p<0.05$). In order to observe the reviewer's attitude toward the information presented, a set of 13 essay reports was used to evaluate and rate scores of each participant, and their assessment ability was estimated. The ability scores of the two groups were comparable, however. Also, the ability scores correlated with scores of session tests of non-discussants, but the relationship was not observed with discussants.

For the development of CTD, a causal relationship between these factors and test scores was examined using a SEM technique, and the differences in the two groups were examined statistically. In the results, there are significant differences in path coefficients of some paths, such as from personality to session test scores and from factor scores of LST to CTD.

A procedure that would attract the participation of more online discussants, and the assessment of its contribution to the development of CTD ability will be subjects of our further study.

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References

Ekahitanond, V. (2013) “Promoting university students’ critical thinking skills through peer feedback activity in an online discussion forum”, *Alberta Journal of Educational Research*, 59(2), pp. 247-265.

Hirayama, R. and Kusumi, T. (2004) “Effect of Critical Thinking Disposition on Interpretation of Controversial Issues: Evaluating Evidences and Drawing Conclusions”, *Japanese Journal of Educational Psychology*, 52, pp. 186-198.

Hoshino, T. and Okada, K. (2006) “Estimation of Causal Effect Using Propensity Score Methods in Clinical Medicine, Epidemiology, Pharmacoepidemiology and Public Health; A Review”, *J. Natl. Inst. Public Health*, 55(3) 230-243.

Kawamoto, S., Nakayama, M. and Saijo, M. (2013) “Using a scientific literacy cluster to determine participant attitudes in scientific events in Japan, and potential applications to improving science communication”, *JCOM*, 12(1), pp. 1-12.

Kawamoto, T., Oshio, A., Abe, S., Tsubota, U., Hirashima, T., Ito, H., and Tani, I. (2015) “Age and Gender Differences of Big Five Personality Traits in a Cross-Sectional Japanese Sample”, *The Japanese Journal of Developmental Psychology*, 26(2), pp. 107-122.

Kline, R.B. (2005) *Principles and practice of structural equation modelling, Second Edition*, The Guilford Press, New York.

Kusumi, T. and Tanaka, Y. (2008) “A development of critical thinking ability during a class of English for Specific purpose”, *JAEP annual meeting*, PF2-35.

Leh, ASC., Kremling, J., Nakayama, M (2012) “Effects of the Use of the blog and discussion board on online teaching and learning”, *Society for Information Technology & Teacher Education International Conference*, 574-579.

Linn, R. L. (1989) *Educational measurement, 3rd edition*, New York, USA: Collier Macmillan Publishers.

Naito, M., Suzuki, K. and Sakamoto, A. (2004) “Development of Rational and Intuitive Information-Processing Style Inventory”, *The Japanese Journal of Personality*, 13(1), pp. 67-78.

Nakayama, M., Kikuchi, S., and Yamamoto, H. (2021) “The development of critical thinking disposition during two online styles of learning”, *Proc. of ECEL 2021*, pp. 314-320.

Nakayama, M., Kikuchi, S., and Yamamoto, H. (2020) “Development of Critical Thinking Disposition During a Blended Learning Course”, *Proc. of ECEL 2020*, pp. 358-364.

Nakayama, M., Kikuchi, S., and Yamamoto, H. (2019) "Lexical Analysis of Online Discussion in a Blended Learning Course", *Proc. of ECSM2019*, pp. 223-230.

Nakayama, M., Kikuchi, S., and Yamamoto, H. (2018) "The relationship between student's characteristics and online discussion activity", *Proc. of ECEL 2018*, pp. 417-423.

Rychen, D.S. and Salganik, L.H. (2003) *Key competencies for a successful life and a well-functioning society*, Hogrefe & Huber Publishers, Boston, USA.

Toyoda H. (2007) *Kyo bunsan kouzou bunseki [AMOS HEN]*, Tokyo Syoseki, Tokyo, Japan.

Trehan, S., Sanzgiri, J., Li, C., Wang, R., and Joshi, R.M. (2017) "Critical discussions on the Massive Open Online Course (MOOC) in India and China", *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 13(2), pp. 141-165.