Revisiting Transactional Distance Theory in e-Learning Environment during COVID-19: Perspective from Computer Science Students

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***Abstract*—This study is based on the separation of teachers and learners caused by the COVID-19 pandemic, and the implication of Moore's Transactional Distance Theory, which proliferated for nearly 30 years but has been inconsistently validated empirically. The quantitative approach was employed, with questionnaires distributed based on the learners' perspectives. The subjects of the study include 153 respondents from computer science department of an Indonesian public university. Three key tenets of transactional distance include dialogue, structure, and learner autonomy were specifically addressed and validated as significant predictors in this study. The findings elucidated an inverse relationship between dialogue and learner autonomy respectively with transactional distance, and a less rigid course structure capable of contributing to lessen the perceived degree of transactional distance in the e-learning environment. Furthermore, this study discovered that e-learning satisfaction and internet connection speed had an impact on the extent of transactional distance.**

***Index Terms*—Computer science students, COVID-19, E-Learning, higher education, transactional distance.**

I. Introduction

The World Health Organization (WHO) reported the Coronavirus disease 2019, or more commonly known as the COVID-19 pandemic on March 11, 2020. There were total of approximately 193 countries including 168 million cases and more than 3.5 million deaths worldwide as of May 27, 2021, caused by COVID-19 [1]. In order to reduce transmission rates and avoid the spread of the disease, the government, public health experts, and all industry authorities have taken significant measures. In the education sector, the school closure initiative has been chosen to shield all learners, educators, and educational staff from high infection pandemics, indeed this action has been recognized as a significant means during previous pandemics [2]-[4].

Thus, online classes and the extensive adoption of technology in all levels of education have taken precedence in order to limit physical contact. Noticeably, the pandemic has caused the educational practice to rely on technological tools and applications, rather than integrating technology to provide teachers and learners with new learning spaces [5]. According to Jung, Horta, and Postiglione, physical campuses will eventually be obsolete, and online learning will provide more educational opportunities while potentially lowering tuition costs [6]. Hence, the use of e-learning and virtual education may perform a significant role in educational practices in the post-pandemic higher education system [7], [8]. As a result, the physical separation between teachers and learners warranted considerations as educational systems progressed toward distance education initiatives.

The present study aimed to investigate the phenomena of e-learning implementation caused by the separation of teachers and learners at the higher education level, through the implication of transactional distance theory. Specifically, three research questions limit the exploration of the study: 1) To what extent do learners experience dimensions of transactional distance in e-learning environments during the pandemic?; 2) What are the effects of dialogue, structure, and learner autonomy on learners' overall degree of transactional distance perceived in e-learning environments during the pandemic?; and 3) What are the effects of demographics, technological resources, and satisfaction of e-learning implementation on transactional distance perceived?.

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II. Theoretical Background

A. Transactional Distance

This study is based on Moore's Transactional Distance Theory, that postulated in 1972, which argued that the separation between teachers and learners is more pedagogical and psychological, rather than merely geographical. Based on the ideas offered by Moore, the higher the degree of transactional distance is negatively affecting the learning outcomes, thus believed need to be reduced in the educational program [9], [10]. Garrison also confirmed that the transactional distance theory is intuitively appealing in examining distance education toward the pedagogical fields [11]. The perceived degree of transactional distance manifested through the interplay of three indicators, dialogue, structure, and learner autonomy [12], [13].

The term "dialogue" emphasized the positive interactions between those involved in the educational environment, which had a series of purposeful, constructive, and valued interactions [12]. According to the initial transactional distance theory, the degree of dialog has an inverse relationship with the extent of transactional distance, i.e., the more dialogic the learning process occurs, the less transactional distance perceived by the students. Delgaty defined dialogue in an e-learning environment as being internalized within the student which can be synchronous or asynchronous [14]. An e-learning course that uses synchronous-mediated communication such as video

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conferencing or a real-time audio-video application (e.g., Google Meet, Skype, Microsoft Teams, Zoom, etc.) results in a highly dialogic process. Moore explains that the use of highly interactive technologies allows the teacher to respond to students more quickly and frequently, presumably achieving a higher degree of dialogue than a recorded medium [13].

Second, Moore conceptualized the structure variable as "a measure of an educational program's responsiveness to learner's individual needs" [15], [16]. The degree of the structure is defined by the application of rigidity or flexibility in educational program objectives, teaching strategies, and evaluation methods [12]. As education has evolved, technology and media have become more involved in the design of learning procedures [17]. Saba argues that a highly structured program was assumed to be the most distant and unresponsive to the needs of the learner [15]. In this endeavor, the perceived degree of structure has a congruence relationship with the transaction distance. Because the teacher may design a high level of course structure very rigidly and rigorously, thus the opportunity for learners to provide input and rearrange the course based on their needs is limited. Moore described a less structure course allows students to seek their own exploration through the YouTube platform, various website sources, and podcasts, to submit assignments at their leisure and to contact teachers only when necessary [13]. Thus, rather than focusing on how a well-designed course is prepared by instructors, the extent of structure in a distance learning environment is determined by the degree of flexibility of courses to meet the needs of students.

Third, learner autonomy is the extent to which the learner is dominant rather than the teacher, to determine the learning objectives, learning experiences, and the means of evaluation of the program [12]. In other words, learner autonomy is the ability of students to design, manage and decide on their educational program. Contrary to the degree of dialogue and structure which fall under the control of educators, learner autonomy is a dimension that includes the learner's side which shows the characteristic and ability of a student to lead their own educational needs. Within the theory of transactional distance, the level of autonomy rises as the degree of transactional distance increases. In other words, a greater degree of transactional distance yields more opportunity and obligation for the learners to practice their learner autonomy [13].

Although the theory has proliferated over the last 30 years, the theory remains pertinent in examining that gap separation while analyzing the emerging indicators that could affect the quality of learning, examples of those empirical studies vary in different modern technology-mediated learning environments such as videoconference [18], web-based environment [19]-[22], distance learning [23], online learning [24], mobile learning [10], social media platforms [25] and e-learning [9], [26]. Notwithstanding of the plethora empirical results attempted by the use of the theory, the nature of the interrelationships among structure, dialogue, and autonomy is not clear [11]. However, the implication of transactional distance theory within this study is expected to provide a useful conceptual lens for exploring the phenomenon of delivering education at a distance, specifically in an e-learning environment.

B. E-Learning Practices during Pandemic

The term "e-learning" has taken on various meanings and nuances over time, sometimes emphasizing content, communication or technology [27]. The Association for Talent Development (ATD) or formerly known as the American Society for Training and Development (ASTD), is credited with coining the term "e-learning". ATD defined e-learning as a structured course or learning content which delivered electronically, including live or pre-recorded lectures, videos, quizzes, simulations and other interactive elements [28]. By adhering the precedence definition, this section discusses common teaching strategies applied by higher education institutions globally during the COVID-19 school closure, such as the real-time live video conferencing, adoption of virtual learning platforms, social media platforms, and recorded lecture videos.

The outbreak prompted live broadcast and recorded video as the most common online teaching practice among the aforementioned learning approaches [29]. It is capable of uniting the separated teacher and student at the same time, or referred to as synchronous mode of learning. Several free-downloaded online communication platforms have also benefited from the sudden transformation of learning, such as the Zoom app, Google Meet, Microsoft Teams, and WebEx. Prior to the outbreak, the use of an online learning platform was thought to be merely a supplement to traditional teaching methods. However, the Indonesian Ministry of Education and Culture established online learning platforms called "Rumah Belajar", which provide sharing learning resources for elementary to secondary school teachers, specifically in response to the outbreak. The "Spada Indonesia" learning management system (LMS) platform established in 2018 to bridge the digital gap in higher education, has only recently gained attention because of the outbreak, as 254 higher education institutions have been integrated into the platform. Similar strategies were also taken by the government of India as the Indian Ministry of Education and University Grant Commission has collaborated and launched several virtual learning platforms, and Massive Open Online Courses (MOOCs) called Study Webs of Active-Learning for Young Aspiring Minds, or commonly known as SWAYAM [7].

Moreover, it could be known that social media tools like WhatsApp, Line, Telegram, Facebook, and other virtual social platforms are popular for supporting online teaching-learning systems during the lockdown period. Sia and Abbas-Adamu contend that social media is able to engage the learning environment and build easy communication between peers as well as lectures [30]. Aside from the live broadcasting approach, which allowed students and lecturers to interact synchronously, recorded videos were also common e-learning modes discovered to be used during campus closure [29]. Synchronous approaches may be challenging for the international students who experience different time zones from their lecturers and origin classmates. The possible solution would be a pre-recorded lecture video to overcome the problem.

III. Methodology

To determine the learner's perceived transactional distance, this study employed a quantitative approach with the distribution of an online questionnaire and addressed the transactional distance tenets include dialogue, structure, and learner autonomy. The research conceptual framework is illustrated in Fig. 1 detailed with the to-be-examined relationship within indicators and their dimensions.

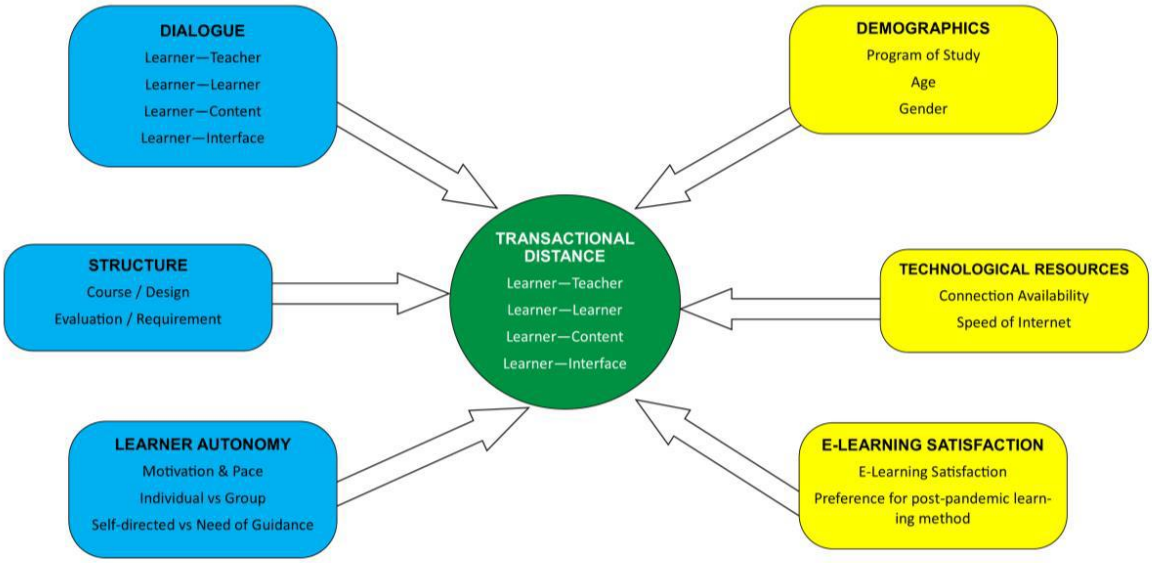

Fig. 1. The conceptual framework within the study.

A. The Subject of the Research

The University of Brawijaya (UB) was purposively selected as the specific subject of this study. UB is a public university located in East Java, Indonesia, which has been affected by the pandemic as it is located in a moderate coronavirus-affected risk city. UB has 16 faculties, consisting of 176 programs of study, and all educational activities and services have been fully transformed online since March 2020. There was a total of 153 respondent from the department of computer science.

B. Instrument

This study developed a questionnaire called "A Survey of E-Learning Challenges and Changes during COVID-19" to assess the perceptions of students in using e-learning during COVID-19 campus closure. The preliminary questionnaire was developed based upon an informal interview with the students of the Department of Computer Science to acknowledge their learning situation and e-learning approaches taken during the pandemic. It also referred to the instrument by Chen in implicated the transactional distance theory in videoconference learning environment [31]. There was a total of 56 items that have been developed and divided into six sections. In particular, forty items addressed the three key elements in the transactional distance theory. The latter part of the questionnaire asked the respondents to describe their access to computers, internet connection, e-learning satisfaction, and preference for future post-pandemic learning methods. The Likert six-point scale was used to indicate the learners' responses throughout the questionnaire. The content validity of this study is established through a review process done by a researcher who is experienced and knowledgeable in transactional distance theory. Further statistical analysis using Cronbach's alpha coefficient to assess the questionnaire's reliability resulted overall of .67.

IV. Results

A. The Extent of Learner Perceived Transactional Distance, Dialogue, Structure, and Learner Autonomy

The present section is displayed with basic descriptive statistics that correspond to students' respond to the questionnaire, Table I detailed the data collected. The four dimensions of dialogue measured using scale 1 indicating "Never" and 6 indicating "Always", which show a relatively high frequency of interaction. The results confirmed that the learner had the highest interaction with their classmates (M=4.63, SD=1.36), followed by the interface (M=4.31, SD=1.79), content (M=4.29, SD=1.33), and lastly the interaction with teacher (M=3.51, SD=1.50).

TABLE I: Descriptive Analysis of Each Dimension

Variable	Dimension	*X*	*SD*
Dialogue	Learner – Learner	4.63	1.36
	Learner – Interface	4.31	1.79
	Learner – Content	4.29	1.33
	Learner – Teacher	3.51	1.50
	Total	4.19	1.49
Structure	Evaluation/Requirement	3.08	1.45
	Course Design	2.81	1.27
	Total	2.95	1.36
Learner Autonomy	Motivation and Pace	4.43	1.15
	Individual vs Group	4.33	1.52
	Self-directed vs Need of Guidance	3.12	1.36
Transactional Distance	Learner – Teacher	3.67	1.01
	Learner - Content	2.98	0.91
	Learner - Interface	2.43	0.98
	Learner – Learner	2.26	1.01
	Total	2.84	1.12

Next, the rigidity of the structure was assessed using scale 1 denoting "Very Rigid", and 6 denoting "Very Flexible". It was discovered that evaluation/requirement (M=3.08, SD=1.45) was more rigid than course design (M=2.81, SD=1.27). The dimension of learner autonomy adopted the six-point scale with the lowest score indicating "Very Untrue" or interdependent learners, and the highest score indicating "Very True" or independent learners. According to the average value, the dimension of motivation and pace received the highest average score of 4.43, which proved that the students were aware of their motivation, and able to manage their learning resources, learning schedule, and assignment during the e-learning implementation.

The transactional distance dimension was also scored on a six-point scale, with the lowest score indicating "Very Distant" and the highest score indicating "Very Close." Since higher values of score correspond to desired low transactional distance, questionnaire responses were reversed prior to data analysis. The mean score revealed that students perceived the most "distant" transactional distance with their lecturer (M=3.67, SD=1.01). In contrast, the perceived transactional distance among learners had the lowest average (M=2.26, SD=1.01). Therefore, this result revealed that the learners experienced less transactional distance with their classmates rather than with their lecturers in the e-learning courses. Corroborated by the result of 139 respondents (90.0%) learners rated "close" distance with fellow students.

B. The Relationship among the Variable within the Transactional Distance Theory

The correlation analysis was conducted to determine the linear relationship among the variables within the transactional distance theory. Pearson's product-moment coefficient was used to interpret the result analysis. According to the bivariate relationship coefficients, the strongest correlation was identified between dialogue and transactional distance ($r(151) = -0.51$, $p < 0.001$), followed by structure and transactional distance ($r(151) = 0.46$, $p < 0.001$), and eventually learner autonomy and transactional distance ($r(151) = -0.36$, $p < 0.001$).

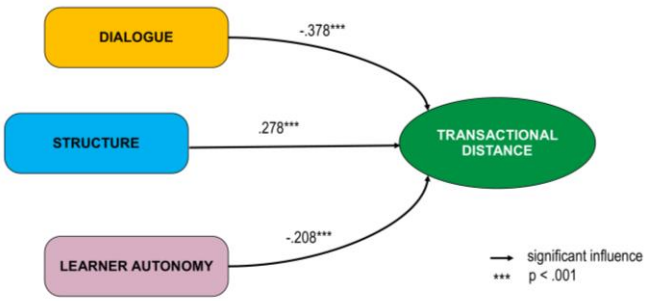

Fig. 2. Result of Multiple regression analysis between dialogue, structure, learner autonomy and transactional distance.

Next, the multiple regression analysis was conducted to determine the extent to which each variable influenced the perceived degree of transactional distance. The results revealed significant relationships of transactional distance and the three variables dialogue, structure, and learner autonomy at the 0.001 level. Separately, this analysis showed that dialogue ($\beta = -0.378$, $t = -5.53$, $p < 0.001$), structure ($\beta = -0.278$, $t = 4.03$, $p < 0.001$), and learner autonomy ($\beta = -0.208$, $t = -3.15$, $p = 0.002$) were all significant predictors of transactional distance in this study, as shown in Fig. 2. Furthermore, the three predictors had a significant collective effect on transactional distance ($F(3,149) = 31.51$, $p < 0.001$), that explained 38.8% of the total variance in the transactional distance.

C. The Effect of Students' Demographics, Technological Resources, and E-learning Satisfaction on Transactional Distance

This section investigated how the program of study, age, availability of technological resources, and e-learning satisfaction, affect perceived transactional distance. Based on the multiple regression analysis. It was found that three demographic variables, namely program of study, age, and gender, were found to have no significant effect on transactional distance. However, it was discovered that only internet speed ($\beta = -0.243$, $t = -2.867$, $p < 0.001$) and e-learning satisfaction ($\beta = -0.486$, $t = -6.107$, $p < 0.001$) had a significant negative impact on perceived transactional distance. According to the regression coefficient, e-learning satisfaction was found to be the strongest predictor among demographics, technological resources, and e-learning satisfaction.

Further analysis on the overall effect variables on transactional distance discovered that, of all independent variables and their dimensions in the conceptual framework (see Fig. 1), three had a significant effect on transactional distance, and all of them had negative impact on perceived transactional distance (see Fig. 3). Learner-learner interaction ($t = -3.81$, $p < 0.001$) of dialogue, awareness of motivation and pace ($t = -4.06$, $p < 0.001$) in conducting e-learning, and satisfaction with e-learning implementation ($t = -2.311$, $p = 0.022$). In addition, there was a significant simultaneous effect ($F(3,149) = 31.51$, $p < 0.001$) between all 15 predictors and transactional distance, which can explain 48.1% of the total variance. Significantly, the regression coefficient revealed that motivation and pace was the strongest factors ($\beta = -0.302$), followed by learner-learner interaction ($\beta = -0.273$), and e-learning satisfaction ($\beta = -0.189$) on predicting perceived transactional distance in e-learning environment.

V. Discussion

The significant finding in answering the first research question indicated that the students experienced a lower extent of dialogue interactions between them and their lecturers. A low sense of communication between students and lecturers during this pandemic, caused by the fact that instead of contacting their lecturers, students had the propensity to construct discussion with their peers to solve the assignments. However, Moore argued that the most valuable interaction in distance e-learning environments is that the interaction between students and teachers, which contradicts the findings of the present study [32].

The perceived degree of transactional distance was the manifested result of interplay between the three tenets variables, which are dialogue, structure, and learner

autonomy. In this study, the inverse relationship between dialogue and transactional distance indicated that more dialogue tends to lessen the transactional distance. This finding supports the stream of prior studies and the first postulated theory which states a polar opposite relationship between the two variables [33]-[35]. Furthermore, the proportional relationship between the structure of program and transactional distance also well confirmed with Moore [12], [32] and previous studies [24], [33], [34]. Therefore, it appears that the dialogue and structure also had an opposite relationship, when there was a rigid structure, it resulted in a reduction the meaningful communication and interaction between those participating in the learning environment [16]. This evidence points to Starr-Glass agreement that the high structure limits the occurrence of dialogue [17]. In this sense, by providing flexibility in the course structure and ample opportunities to engage in dialogue with lecturers and peers is expected to reduce the transactional distance in the e-learning environments for the computer science learners as the subject of this study.

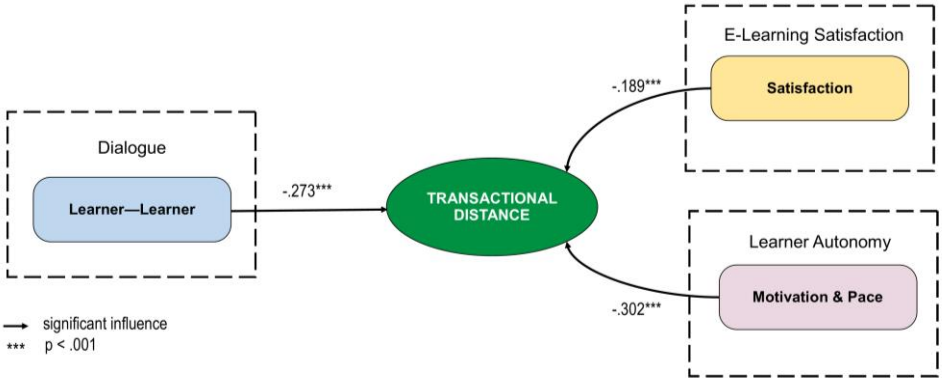

Fig. 3. Result of multiple regression analysis of overall effect of all dimensions on transactional distance.

Moore explicated the relevance of the third element in transactional distance, which is learner autonomy [13]. The varying levels of dialogue and structure also believed to interact with the extent to which students in managing their own learning and having the voice in designing and executing the course program. Regardless of the lecturers' physical absence during the campus closure enactment, the level of interaction between teachers and peers will remain determine the degree of learner autonomy [11]. The rigidity or flexibility level of course structure also able to impact the ability or learner to control the learning process [36], which in turn trains students' autonomy. Moore posits that the learner autonomy and transactional distance shared a negative relationship, which explains that as transactional distance increases, learners must increase their autonomy to cope with the psychological separation [12], [13]. The postulation also well verified through the result of this study.

According to the overall effect analysis, all dimensions on transactional distance revealed that motivation and pace in conducting e-learning, interaction among learners, and level of satisfaction in e-learning implementation were significant predictors, respectively. Motivation in e-learning is regarded as the most important factor in this study, owing to the separation of learner and teacher, because of that learner must accept responsibility for their own learning path [37]. Furthermore, the pace in an e-learning environment is an important factor, as evidenced that perceived transactional distance is reduced when learners control their learning pace [38].

VI. Conclusion and Recommendation

This study revealed a new avenue for the implication of the transactional distance theory in the setting of e-learning environment at the higher education level, specifically in the computer science department environment. The comprehensive results demonstrated that the three variables within the transactional distance theory were significant predictors in the model. Moreover, an overall effect analysis revealed that learner-learner interaction, motivation and pace awareness in performing e-learning, and e-learning satisfaction had significant negative effects on perceived transactional distance.

Consequently, the significant relationship between dialogue and transactional distance builds an understanding of how important purposeful interaction is in distance education settings. Therefore, the findings implying that instructors should encourage high levels of dialogue among learners and between learner-instructors, focusing not only on frequency but also on quality communication which incorporates more interactive and engaged communication to ease the psychological distance. In regard to remain consistent with the finding that the extent of motivation and learning pace awareness was highlighted to be the strongest predictor in this study. Thus, there is an urgent need to design a less rigid course structure to equip students with space for their own exploration and the ability to control their own learning pace. Furthermore, this study was able to incorporate the e-learning satisfaction into the transactional distance theory conceptual model. According to this study, students with higher level of satisfied learning experience perceived lower transactional distance.

Finally, while this study focused on the implementation of e-learning from the perspectives of learners from the computer science department, it is necessary to broaden the range of samples and explore various learning fields to allow the generalization of findings. Diverse research subjects may generate new research questions when comparing the perceived degree of transactional distance in multiple

learning environments, and shedding new light on the theoretical construct. To comparing the impact of synchronous and asynchronous learning methods on perceived transactional distance would also allow for further verification of the theory. Eventually, examining the paradigm of Moore's Transactional Distance Theory in different learning settings with a diverse population may provide a fuller insight for facilitating e-learning students.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

MS conducted the research, analyzed the data, and wrote the paper. YC contributed to the design, development, and analysis of the study. All authors had approved the final manuscript.

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