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Realtime online courses mutated amid the COVID-19 pandemic: Empirical study in hospitality program

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ABSTRACT

Real-time online courses (RTOCs), a new online learning mode, have been developed because of a longitudinal suspension of classes amid the COVID-19 pandemic worldwide. We explore an information model to review the learning process and outcomes of RTOCs, which conducted educational activities via social media. Results show that social media can be a potent mediation factor with the moderation of structural differentiation to facilitate online learning outcomes. Conclusions imply that the life-changing impact of COVID-19 has caused an evolutionary online education mode that can be hybridized with face-to-face education and massive open online courses to flourish education approaches and pedagogies.

1. Introduction

The blend of traditional learning and massive open online courses (MOOCs) has adaptive evolution and progressive technology development (López-Pérez et al., 2011). The evolution of education modes is smooth as expected. However, the COVID-19 pandemic has impacted the world, including education (Karalis & Raikou, 2020). The highly mutated Omicron variant has led to severe infections that governments need to delay the implementation of pandemic control strategies (Poudel et al., 2022). This study aims to argue that real-time online courses (RTOCs) are becoming a new muted educational approach, which needs echoing pedagogies in education. Starting from the spring of 2020, the pandemic caused schools to lockdown campuses and forced teachers and students to initiate online learning (Bao, 2020). Many schools require teachers and students to adopt real-time online courses (RTOCs) complemented with MOOCs during the long-term suspension of face-to-face learning activities (Peng et al., 2020). The suspension of classes without suspending learning amid the pandemic has become the prevailing phenomenon among schools (Jung et al., 2021). Schools require teachers and students to adopt online resources, such as social media, to conduct teaching and learning activities even if such platforms were not designed for education (Al Lily et al., 2020). Significant issues were encountered on the educational demand and supply sides during RTOCs in the beginning. Most teachers and students were not trained to apply social media in RTOCs (Kaplan & Haenlein, 2016). Social media functioned as an educational platform but crashed all the time because of the over-demand for capacity (Chen et al., 2020). The facilities and resources failed to handle the excess demand during the pandemic. However, RTOCs were frequently used and matured with the improvement of supply and demand capabilities when the pandemic persisted for more than one year worldwide (Brown, 1993). The pandemic has already mutated into a new education mode for teaching and will persist in the

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future (Taglietti et al., 2021).

This study explores the RTOCs' learning process and outcomes. RTOCs adapt several social media platforms to transmit educational information between educators and learners. No single social media platform can offer complete functions for various subjects among schools (van Bommel et al., 2020). Teachers may require students to use Zoom for meetings (Kohnke & Moorhouse, 2020), Rain Classroom for in-class exercises and interactions (Li et al., 2021), Moodle for forum discussions (Dascalu et al., 2021), and Google Forms for quiz evaluation (Afiah & Pujiastuti, 2021). These social media help RTOCs facilitate knowledge transmission when face-to-face and MOOCs are not applicable. However, information leakage occurs because of the inconsistency of the information platforms; that is, information entropy increases to raise the chaos of the new education ecosystem between educators, students, and social media (Allen et al., 1996; McDermott, 2022). Thus, we extract the factors of information and social media with structural differentiation to explore the learning outcomes of the RTOCs-efficiency model. The objective is to observe the evolutionary mutation of RTOCs parallel with face-to-face and MOOCs learning.

2. Literature review

2.1. Evolution from traditional education, MOOCs to RTOCs

Education evolves with social and cultural changes (Baker, 2014) and technology development, especially the influence of social media (Shulla et al., 2020). Traditional education conducts face-to-face teaching and learning activities in physical schools, where teachers and students gather together for knowledge transformation (Dede, 1996). However, the school's territory also forms a barrier to prevent students who are not registered (Reich, 2020). Some top schools have abundant resources that can only be shared with upper-level students (Oakes, 1986). The uneven distribution of educational resources was allocated to different levels of students with diverse social classes, resulting in the icing-on-the-cake phenomenon of traditional education (Xing, 2013). Therefore, endeavors have been made to initiate MOOCs with online learning pedagogy since 2012 to be more oriented toward social justice (Bali et al., 2020; Gaebel, 2014). Equality opportunity in humanism is a guiding philosophy for education (Tamrat, 2020).

MOOCs emerged at the end of the 19th century and followed technology and Internet development (Kalman, 2014) to release some educational resources to break inequality. Schools' courses have opened to the public for free through the Internet, facilitating massive online courses to break through traditional education boundaries (Sandeen, 2013). Many differences have been observed between MOOCs and traditional education regarding educational cost, resources, personalized learning, interactivity, and evaluation (Daniel et al., 2015). However, pure online education cannot substitute traditional education. MOOCs are not in line with the local customization of education (Germain, 2020). Furthermore, the unequal distribution of education resources still exists because MOOCs are a supplementary educational pathway for traditional education (Lambert, 2020).

Education has evolved from face-to-face teaching, from MOOCs to hybrid pedagogies (Defaweux et al., 2019). However, the COVID-19 outbreak suddenly suspended the traditional approach to control and prevent the pandemic. MOOCs were unable to become an alternative because of the pedagogy's nature and the lack of interaction in real-time interaction (Sinclair & Kalvala, 2016). RTOCs through social media are recommended during schools' shutdowns because of teaching and learning obligations, better time management, and similar teaching and learning arrangements. However, RTOCs had problems when it was first implemented. For example, teachers and students could not run RTOCs smoothly because of the incapability to use social media for teaching and learning (Jogezai et al., 2021). On the supply side, social media cannot quickly handle the vast volume of excess demand. After a long-term accommodation, both sides of RTOCs started evolving as a regular educational mode, from quantitative to qualitative changes (Jacobson et al., 2019). The demand side has gained substantial improvements in the capability of RTOCs, and the supply side has invested strategic resources to attract educational users. Social media investments are expected to continue, such as the regeneration and use of Olympic investments after the games (Gold & Gold, 2020). A new approach, RTOCs, is added to multiple paths like traditional education and MOOCs to form the hybrid education system (Nguyen, 2015).

2.2. Use social media for RTOCs

2.2.1. Information system and learning outcome

Education is a typical information transmitting and processing system, where teachers deliver information to students through pedagogies (Loughran, 2013). Despite the recent growth of tutorship and mentorship to stimulate students' self-learning (Kirillova & Au, 2020), most teaching activities have mainly adopted the transmission-reception mode to deliver information to students (Z.-g. Wang, 2007). These teaching modes dovetail with two main research streams in how information influences learning outcomes (Hosier, 2017). The first stream focuses on teaching (Barber & Moursheed, 2007; Darling, 2000; Yin et al., 2016). Fauth et al. (2014) proposed three dimensions of teaching quality, namely, classroom management, cognitive activation, and supportive climate, suggesting that teachers should maintain a quiet learning environment, stimulate students' critical thinking, and provide continuous support to help information transmission.

The second research stream focuses on learning how information learned by students helps achieve better learning outcomes, including six levels of Bloom's taxonomy of cognitive development (Abbasi & Kazi, 2014; Bloom et al., 1984). Students obtain information from teachers, teaching materials, and facilities (Z. Wang, 2007). Many schools invest in various information resources to help students digest information (Serenko et al., 2012). The effectiveness of these information resources relies on students' learning desires and how these information resources are organized for students to choose, evaluate, and use. Based on these two perspectives, this contention stems from behavioral theories that highlight that teachers should transmit the knowledge well-organized (L. Wang,

2007) and students should learn with resources. Thus, many studies have adopted information literacy in the online learning environment to design an educational information system that assists teachers and students in processing and handling learning outcomes (Detlor et al., 2011; Samson, 2010).

H1. Information positively influences learning outcomes.

2.2.2. Information and social media

The educational information system has evolved from traditional face-to-face education with the supplement of MOOCs via information platforms (Bralić & Divjak, 2018). The RTOCs via social media are chosen as an alternative mode when suspending classes during the pandemic when face-to-face activities and MOOCs are not applied (Ali, 2020). We stated that social media had improved their facilities and capacities to meet the requirements of RTOCs (Afiah & Pujiastuti, 2021; Dascalu et al., 2021; Gold & Gold, 2020; Li et al., 2021). A research gap in investigating how RTOCs were utilized to build an effective information system can help students achieve better learning outcomes (Azevedo et al., 2021).

H2. Information positively influences social media.

2.2.3. Social media and learning outcome

The sudden education mutation, RTOCs conducted via social media, introduces deviations to the existing educational information system. Many institutions have utilized RTOCs through various social media platforms, such as Zoom, MS Teams, and WeChat RC, which are not tailored for teaching purposes (Afiah & Pujiastuti, 2021; Dascalu et al., 2021; Feng et al., 2019; Li et al., 2021). These platforms bring many uncontrollable factors influencing students' learning outcomes (Scherer et al., 2019), for example, technical issues, infeasible monitoring of students' learning progress, and test cheating (Rasheed et al., 2020). However, the long-term high-frequency adoption of RTOCs amid the pandemic has changed from quantitative to qualitative improvement of learning outcomes (Azevedo et al., 2021).

H3. Social media positively influences learning outcomes.

2.2.4. The mediation effect of social media

COVID-19 persists in causing RTOCs continuous somewhere with severe confirmed cases. Large-scale national resources have been invested in supporting remote learning during the COVID-19 pandemic period (Ali, 2020). RTOCs were taught and learned through social media and have become mainstream educational activities because of the failed adoption of face-to-face and MOOCs learning (Kumar & Vulichi, 2021). Teachers and students have adopted RTOCs via social media for knowledge transmission to achieve learning outcomes (Linder, 2021). For example, students joined social media for online learning, teachers turned to social media to conduct online courses, and assessments could be conducted online (Rasheed et al., 2020). Finally, these teaching and learning activities were quickly adopted because social media evolved with the education requirements (Reimers, 2022).

H4. Social media plays a mediating role between information and learning outcomes.

2.3. Structural differentiation in educational information system

Shannon (1948) pioneered developing a mathematical model called information entropy using probability theory to calculate information quantity based on the information volume transmitted within a unit of time. This model stems from studies of uncertainty to eliminate information chaos that cause the information to sink in the information source channel (Wang & Li, 2003). It has widely been applied in different study fields, such as information system (Liang et al., 2006), medicine (Tsai et al., 2008), and manufacturing (Jung et al., 2011), to evaluate the information delivery process in influencing people's behavioral and physiological responses (Jing et al., 2018). Although education is an extensive information system, it has received limited academic attention on eliminating information entropy. Few studies include Z. Wang (2007), who considered four interventions to determine information entropy at the end of the teaching process: teachers' knowledge, teaching methods, teaching experience, and expression ability, defined as teachers' individual capability. These four factors focus on the teacher's capability in the teaching process (Lei & So, 2021; Marfuah et al., 2022). In addition, Sheng et al. (2017) focused on the teaching level assessment. Other factors were discussed on the structural differentiation of educational information systems. Qu et al. (2015) advanced it by incorporating other class management interventions, for example, the flexibility of teaching activities and the proportion of teaching time to determine information transmission quality and predict information entropy. We defined interventions from institution rules. The literature has also viewed the application of information technology in learning activities in an optimistic way, suggesting that information technology can help students achieve better learning outcomes through improving information technology capability (Sugandi & Kurniawan, 2018). For example, Rusmono et al. (2019) adopted an experimental approach to demonstrate that mobile teaching resulted in a 16.8% increase in students' learning outcomes. The pandemic has forced many institutions to utilize various social media platforms for RTOCs with their institution rules and training teachers and students' technology capabilities to reduce educational information entropy.

Educational mutation happens when the capability is enhanced on the demand side and resources are invested on the supply side. RTOCs will not disappear after the pandemic because educational mutation has become irreversible between stakeholders' intangible capability and tangible investment in RTOCs. A pedagogy that can meet the characteristics of RTOCs is also necessary to develop the multi-pathway with traditional education and MOOCs.

H5. Structural differentiation plays a moderating role between social media and learning outcomes.

3. Methodology

3.1. Research model

Information influences knowledge integration and learning outcomes during knowledge exchange because of enhanced activation (Erkens & Bodemer, 2019). When traditional face-to-face teaching and learning activities were suspended amid the pandemic, social media platforms, such as the video-conferencing platform Zoom, were widely adopted as the pathway for RTOCs (Ali, 2020; Kohnke & Moorhouse, 2020). However, social media was not tailor-made to educational purposes that influence the learning outcome's effectiveness (Feng et al., 2019). The moderation of structural differentiation is necessary to resume teaching and learning systems (Scherer et al., 2019). Social media can then be a reliable mediation channel between educational information and learning outcomes as a new pathway of knowledge transformation amid or after the pandemic (Lee et al., 2019). The moderated mediation educational model of RTOCs through social media is constructed in Fig. 1.

3.2. Research design

The RTOCs measurement tool consisted of four constructs: information, learning outcome, social media, and structural differentiation. The eleven items in information focus on measuring information accessibility and usability (Lee et al., 2002). Learning outcome consists of two dimensions, essential ability and creative ability, with six items of learning outcome (Chauhan, 2014). Social media consists of eleven channel functionality items and four function items. Social media measures the degree of providing the educational content in the teaching and learning activities (Bertot et al., 2006; Tandon et al., 2016, 2018). The structural differentiation of social media measures institutional rules (Chen et al., 2015; Hina et al., 2019) and individual capability (Evans et al., 2014) (Appendix 1).

The study is conducted in the Chinese Mainland, Hong Kong SAR, and Macau SAR. Data were collected by recruiting 956 respondents; 926 responses were adopted after the valid screening through a cooperative survey company. A random sampling of targeted groups was required when outsourcing the data collection to the survey company Wenjuanxing, a platform with a majority of population database providing functions equivalent to Amazon Mechanical Turk. We asked the company to deliver the designed questionnaire to teachers and students in hospitality programs.

Reliability and validity of all constructs showed that the questionnaire is proper for measurement (Appendix 2). Data analysis applied the structural equation model with Mplus to examine the CFA model and research hypothesis (Byrne, 2013).

4. Results and discussions

4.1. Profile of respondents

Among the survey respondents, 24.5% were teachers, and 75.5% were students. Among them, males accounted for 38.2%, and females accounted for 61.8%. Approximately most of the respondents were younger than 30 years old. Specifically, 36.2% were under 20 years old, 41.7% were 21–30 years old, and 16.5% were 31–40 years old. The vast majority of respondents had a university education; 66.8% of the respondents' teaching/learning area was in Chinese Mainland, 33.2% were in Hong Kong SAR and Macau SAR, 90.5% lived in Chinese Mainland, 3.8% and 4.8% live in Hong Kong SAR and Macau SAR, respectively, and only 0.1% lived in Taiwan. Table 1 shows the demographic of the survey sample.

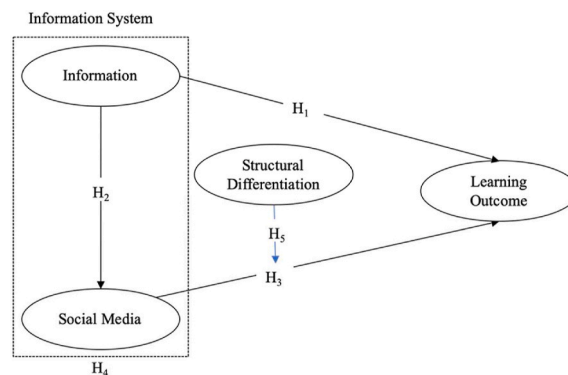


Fig. 1. The intervention model of RTOCs.

Table 1
Descriptive statistics of respondents' characteristics.

Items	Classification	Frequency	Percentage (%)
Identity	Teacher	227	24.5
	Student	699	75.5
Gender	Male	354	38.2
	Female	572	61.8
Age	20 or below	335	36.2
	21–30	386	41.7
	31–40	153	16.5
	41–50	46	5
	51–60	5	0.5
Education	61 or above	1	0.1
	High school	21	2.3
	Bachelor's degree	677	73.1
	Master's degree	179	19.3
Current living area	Doctor's degree	49	5.3
	Chinese Mainland	838	90.5
	Hong Kong SAR	35	3.8
	Macau SAR	44	4.8
	Taiwan	1	0.1
Teaching/learning area	Other	8	0.9
	Chinese Mainland	619	66.8
	Hong Kong SAR and Macau SAR	307	33.2

4.2. The measurement model

Reliability and validity values for constructs all meet the measurement requirements. The average variance extracted values are all above 0.5 to fit the validity criteria. Composite reliability values ranged between 0.816 and 0.899, all above 0.7. Cronbach's alpha values ranged from 0.807 to 0.897, all above 0.7 (Appendix 2). The standardized results obtained from the structural model, after 1000 bootstrap iterative calculations in Mplus, show that the data fit the model well: $\chi^2(df) = 2.95$, RMSEA = 0.046, CFI = 0.914, TLI = 0.908, SRMR = 0.041. The loading index for a given construct exceeded that of other constructs' loadings, reflecting discriminant validity, as shown in Table 2.

4.3. Mediation analyses of social media

We tested the mediation effect of 1000 bootstrap samples by Mplus and found that social media was significantly related to information ($\beta = 0.919$, $p < 0.001$) and learning outcomes ($\beta = 0.718$, $p < 0.001$). However, after the mediation effect of social media, the relationship between information and learning outcome is insignificant ($\beta = 0.201$, $p > 0.5$). The direct effect of the mediating effect between information and learning outcome was insignificant, which indicated that social media plays a full mediator role between information and learning outcome. Therefore, H_4 is supported. Table 3 shows the results of the mediation model.

4.4. Moderation analyses of structural differentiation

Fig. 1 demonstrated that structural differentiation has a moderation effect between social media and learning outcomes. The standardized coefficient from "social media*structural differentiation" to learning outcome was -0.056 ($p < 0.05$), which illustrated that the moderation effect was statistically significant. Furthermore, we picked low and high moderator values for structural differentiation and added or subtracted standard deviation below the mean value of moderating variable (structural differentiation: 3.86 ± 0.84). Then, we conducted path analysis in Mplus. Fig. 3 intuitively provides evidence of the moderating effect of structural differentiation on social media and learning outcomes. The statistically significant interaction between social media and learning outcome shows that the positive correlation between social media and learning outcome is robust at a lower level of structural differentiation. In comparison, at a higher level of structural differentiation, the positive correlation between social media and learning outcomes is weaker.

Consequently, the moderating variable of structural differentiation exerted a negative moderating effect on the second stage of the indirect effect between social media and learning outcome. Thus, structural differentiation played a moderating role in social media

Table 2
Discriminant validity.

	IN	LO	SM	SD
Information (IN)	1			
Learning outcome (LO)	0.759	1		
Social media (SM)	0.866	0.752	1	
Structural differentiation (SD)	0.859	0.774	0.870	1

Table 3
Standardized direct, indirect, and total effects.

	Estimate	Product of coefficient		95% Confidence interval (1000 bootstrap samples)	
		S.E.	Est./S.E.	Lower	Upper
Total Effect	0.919***	0.036	25.814	0.849	0.993
Indirect Effect	0.718***	0.177	4.064	0.452	1.160
Direct Effect	0.201	0.186	1.079	-0.254	0.508

Note. Values represent standardized regression coefficients. *** $p < 0.001$.

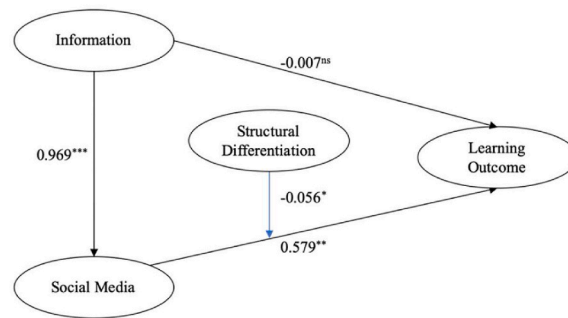


Fig. 2. The testing model.

Note. Values represent standardized regression coefficients. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

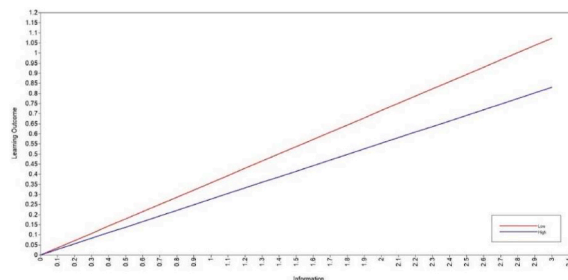


Fig. 3. Relationship between information and learning outcome at different levels of structural differentiation.

and learning outcomes. H_5 was supported accordingly.

Based on the statistical findings, the five inter-construct relationships were re-summarized in Table 4, together with the empirical results of supported H_1-H_5 .

4.5. Discussions

4.5.1. Model interpretation

Fig. 2 and Table 4 show that the structural model of RTOCs is sustained. The results prove that educational information systems, including social media, can offer intervention functions to maintain learning outcomes. Hypothesis 1 is significant with a negative path coefficient that tells the advert effect of learning from chaotic information, especially when RTOCs were first introduced. Teachers and

Table 4
Standardized path coefficients for structural mode.

Hypothesis	Standardized path coefficient	Testing result
H_1 : IN→LO	-0.007 ^{ns}	Not Supported
H_2 : IN→SM	0.969***	Supported
H_3 : SM→LO	0.579**	Supported
H_4 : IN→SM→LO	0.718***	Supported
H_5 : SD on SM→LO (moderation effect)	-0.056*	Supported

Note. Values represent standardized regression coefficients. * $p < 0.05$; *** $p < 0.001$, ns: insignificant.

learners should adopt proper social media to conduct educational activities when classes are suspended because of the prevention and control of the pandemic. This action also accords with earlier observations, which showed that information helps achieve better learning outcomes (Abbasi & Kazi, 2014; Wang, 2007), especially during a pandemic. However, social media's direct (H_2) and indirect effects (H_4) have converted the learning effect into positive outcomes that show the remedy measures from technology. Although the beginning stage of RTOCs is orderless, later social media helps teachers and learners interact, get accustomed to the online learning environment, and improve learning outcomes. This study supports evidence from previous observations (e.g. Linder, 2021; Bralić & Divjak, 2018). It shows that the RTOC mode is a helpful alternative when face-to-face educational activities are suspended and MOOCs are not suitable. It also further supports the idea of Ali (2020) that the RTOCs via social media are chosen as an alternative mode. The moderation effect of the structural differentiation of institutional rules and individual capabilities in social media can also reduce the information entropy to raise the learning effects (H_5) (Matei & Britt, 2017). The result expands the understanding of structural differentiation on the basis of previous studies of Bo (2019). Educational authorities could lead the choice of social media, suggest few media that most teachers and students accept, and train teachers and learners to improve their technical ability to use social media for teaching activities. These measures could help reduce the chaos and uncertainty of the information system used to conduct teaching and learning activities for learning outcomes.

4.5.2. Adoptive pedagogy for the evolution of the RTOCs

The sudden emergence of RTOCs in China, Hong Kong SAR, and Macau SAR has evolved into an evolved educational approach amid the pandemic. Teachers and students on the demand side have strengthened their online teaching and learning abilities. Social media platforms on the supply side have also up-scaled their hardware and software facilities. A new RTOCs ecosystem evolved to a third education approach beyond traditional face-to-face courses and MOOCs in China, Hong Kong SAR, and Macau SAR. The RTOC model has become a robust education system that needs echoing pedagogies to confront the fluctuating circumstances of the pandemic. Knowledge transformation parallels traditional mode and MOOCs because of the prolonged pandemic from 2019 to 2022. The RTOCs are not concerned about what kinds of social media platforms have been applied. The most crucial issue is to achieve students' learning outcomes, which are provable education content (Kennedy, 2006), transformative knowledge, empathy analysis, and action capabilities (Munroe & Pearson, 2006). RTOCs help the knowledge conversion process achieve learning outcomes into the cognitive, skill, and attitude capabilities (Halawi et al., 2009). Nevertheless, the RTOC intervention model is necessary to form its adaptive pedagogy that can guarantee the qualifying role of education on the evolving pathway.

5. Conclusions

5.1. Conclusion

The education evolution moves from traditional face-to-face to MOOCs modes smoothly and advanced information technology until the end of outbreaks and prolonged pandemic circumstances. The pandemic has led to a sudden muted RTOC mode when teaching and learning happen despite restricted campus access, similar to the condition in the Greater China regions. Educational information transmission to learning outcomes could be chaotic without the intervention of information systems and institutional governance during the pandemic. While the pandemic variant Omicron is still raging, the RTOCs have become a multi-channel of teaching and learning after a long-term adaptation of educational information supply and demand requirements. An echoing pedagogy is needed for the mutated educational mode implemented with the traditional face-to-face and MOOCs approaches.

5.2. Research implication

The practical implication of this study is that the continuous COVID-19 variants have sustained RTOCs, which have become a new teaching and learning mode that complement face-to-face and MOOCs approaches during the changing conditions brought by the pandemic. The mixed-mode has been applied to educational activities and the fluctuating circumstances of the control and prevention measures of the pandemic. The policy of class suspension without suspending learning amid the pandemic via RTOCs has prevailed for areas with severe confirmed cases. After adopting remote teaching and learning through social media for educational activities during a period, teachers and students were trained to use RTOCs for students' learning outcomes. Social media has dramatically improved facilities, equipment, bandwidth, and network speed to meet educational requirements on the technology supply side. The intervention of institution governance was also exercised effectively in the new educational ecosystem. The RTOC mode has evolved from quantitative adoption to quality improvement to parallel development with face-to-face education and MOOCs. Even though the pandemic has negatively influenced our education system, educators and students have found their way out for continuous learning.

5.3. Recommendation

This study recommends getting used to the multi-channel teaching and learning approaches following the tight or relaxed pandemic prevention measures caused by COVID-19 variants. The RTOCs have been parallel to the face-to-face approach for some students who may be quarantined because of the special pandemic conditions. Thus, institutions need to design an educational media platform suitable for RTOCs since many regions have prolonged control and prevention measures. The RTOC mode has evolved to be a parallel educational approach with traditional face-to-face education and MOOCs at different times and places in need. The hybrid online and offline parallel educational approaches should also come out with mixed pedagogies. The pandemic's influence persists

even though it caused the education system’s initial disorder. However, the mutated educational ecosystem for continuous knowledge conversion and transmission may be suitable for education systems to accumulate experiences to deal with similar situations in the future.

Author statement

Kang-Lin PENG: Conceptualization, Methodology, Formal analysis, Model construction, Writing- Original draft preparation, Supervision. **Pearl M.C. LIN:** Resources, Data curation, Writing - Review & Editing, Validation. **Jusi Xu:** Software, Writing- Reviewing and Editing. **Xin Wang:** Writing - Review & Editing.

Appendix 1. Variable measurement

Constructs	Dimensions	Items	Reference
Information		Course information has rich online links. Course information has good content. Course information is easy to obtain. Course information is easy to retrieve/search. Course information is delivered without hindrance. Course information is easy to understand. Course information is valuable. Course information is trustworthy. Course information has high quality. Course information is objective. Course information is safe.	
Learning outcome	Basic ability	Level 1: Able to remember learning content Level 2: Able to understand the learning content Level 3: Able to apply learning content and solve problems	
	Creative ability	Level 4: Able to analyze the details of learning content or causality Level 5: Able to evaluate the value of learning content, judge the pros and cons, and make decisions Level 6: Able to reorganize, create, and innovate knowledge	
Social media	Channel	Social media provides an information channel for knowledge transfer. Social media provides information channels to resolve confusion. Social media provides information channels for learning activities, such as inter-class activities and homework exercises. Social media provides an information channel for teacher-student interaction. Social media provides an information channel for group discussions. Social media provides information channels for sharing information. Social media provides diverse and rich educational information. Social media provides educational information needed for learning. Social media provides educational information that promotes learning. Social media provides real-time updated educational information.	
	Function	Social media provides a channel to submit assignments/reports. Social media provides trusted educational information. Social media provides a platform for oral reporting. Social media provides a platform for subject examinations. Social media provides the function of automatic scrolling.	
Structural differentiation		Information control can improve the degree of information integration. Information control can implement organizational vision, plans and structure. Information control can cooperate with information management organization and functions. Information control can reduce organizational heterogeneity. Information control is a key mechanism for organizational security. The information control mechanism should be developed from top to bottom (from the top of the organization to the grassroots). Information control provides a blueprint for teaching/learning development. The knowledge and experience of educators will form an information control mechanism. Information control can guide teaching and learning. Information control can ensure teaching/learning quality.	

Appendix 2. Reliability and validity of all constructs

Constructs	Items	Factor loadings	CR	AVE	Cronbach’s α
Information	IN1	0.682	0.899	0.547	0.897

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Constructs	Items	Factor loadings	CR	AVE	Cronbach's α
Learning outcome	IN2	0.659	0.816	0.528	0.807
	IN3	0.651			
	IN4	0.648			
	IN5	0.627			
	IN6	0.670			
	IN7	0.708			
	IN8	0.666			
	IN9	0.716			
	IN10	0.684			
	IN11	0.637			
	Social media	BAS1			
BAS2		0.670			
BAS3		0.754			
CRE1		0.718			
CRE2		0.621			
CRE3		0.538			
CHAN1		0.660			
CHAN2		0.624			
CHAN3		0.597			
CHAN4		0.588			
CHAN5		0.568			
CHAN6	0.630				
CHAN7	0.674				
CHAN8	0.683				
CHAN9	0.646				
CHAN10	0.624				
CHAN11	0.619				
Structural Differentiation	FUNC1	0.580	0.897	0.566	0.895
	FUNC2	0.554			
	FUNC3	0.593			
	FUNC4	0.488			
	SD1	0.749			
	SD2	0.690			
	SD3	0.707			
	SD4	0.607			
	SD5	0.678			
	SD6	0.612			
	SD7	0.709			
SD8	0.716				
SD9	0.687				
SD10	0.655				

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