Online teaching self-efficacy during COVID-19: Changes, its associated factors and moderators

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Abstract

Online teaching transition during COVID-19 school lockdown elicited challenges for teachers and schools across the globe. The existing literature on the impact of COVID-19 in the education sector is predominantly descriptive and focused on the difficulties faced by teachers during the process of transferring into online teaching, mainly in the higher education sector. This study adopted a mixed-method design to examine online teaching self-efficacy (TSE) during COVID-19, its associated factors and moderators. A sample of 351 Chinese school teachers retrospectively reported their online TSE at the beginning and end of COVID-19 school lockdown, out of which six were followed up for an in-depth interview. TSE for online instruction did not significantly increase ($\beta = .014$, $p > 0.05$) whereas that for technology application increased significantly ($\beta = .231$, $p < 0.01$). Lack of experience in online teaching, separation of teachers from students, school administrative process and unsatisfactory student academic performance were identified as the major associated factors. A moderation effect of adaptability and teacher burnout on the change in online TSE were examined, of which passion burnout was the only significant moderator toward the change in online TSE. The study thus concluded that teachers' online TSE for technology application increased among Chinese teachers during COVID-19 school lockdown.

Keywords Online teaching · Teacher self-efficacy · COVID-19 · China

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1 Introduction

Online teaching transition caused by school lockdown during the 2019 corona virus pandemic (COVID-19) has led to a number of challenges both from the teachers' and the students' perspective. The first half of 2020 witnessed schools lockdown across 172 countries, which impacted the education of approximately 1.5 billion students/learners (United Nations Educational, Scientific and Cultural Organization, UNESCO 2020). In China, the majority of primary and secondary schools, with an estimated 200 million students commenced online teaching in the middle of February 2020 (Ministry of Education of the People's Republic of China, [MEoPRC] 2020a).

With de-escalation of the COVID-19 situation in China, a gradual reopening procedure came into place. Approximately one-fifth of students returned to their schools at the end of April 2020 (China Education Online 2020) and till the middle of August, the percentage reached approximately 75% (MEoPRC 2020b). All schools were required to recover their face to face teaching for the autumn semester, which commenced in September 2020 (MEoPRC 2020b). However, much is still unknown about the nationwide practice of online teaching across all levels of schools in the country.

2 Literature review

2.1 Online teaching before and during COVID-19

Various forms of online teaching have been in existence prior to COVID-19, including a range of online open courses and distance education. In China alone, over 500 universities teach online courses to more than 3 million learners (Shang and Cao 2017). The need to replace physical classroom with online teaching cannot be over-emphasised at the time of natural disasters or crises. In New Zealand for instance, various schools and universities in Christchurch city, including the University of Canterbury were forced to adopt online teaching because of the 2011 earthquake (Tull et al. 2017). Similarly, in South Africa, many universities transferred their teaching online during the period from 2015 to 2017 due to the shutdown of campuses caused by student protests (Czerniewicz et al. 2019). Accordingly, online teaching became intensified and necessary in various countries as a result of COVID-19.

While online teaching is not a new phenomenon, the transition to online teaching as a result of COVID-19 brings about a number of challenges from both the teachers' and the students' perspective. These challenges were associated with the separation be-tween teachers and their students as opposed to the conventional classroom teaching (Moore 2014) and/or lack of online teaching experience (Johnson et al. 2020). The separation leads to the difficulty for teachers in their ability to communicate effectively with students as well as restricting them from generalising the teaching ability devel-oped in the physical classroom into the online contexts (Putri et al. 2020). For instance, teachers can enhance the teacher-student connectedness using facial expressions and body languages, whose influences could be affected in an online context, which leads to greater reliance on voice communication (Bao 2020). Other challenges have been reported in teachers' difficulties in the application of information-communication

techniques, interaction with students, organising online learning resources and lack of sufficient facilities for students (Verma et al. 2020). Similarly, Putri et al. (2020) reported the challenges faced by secondary mathematic teachers in Indonesia into three categories: individual teachers lack of confidence in online teaching and required knowledge; schools failure to provide sufficient technological supports for online teaching; and poor students' online learning habits.

Compared with the physical classroom teaching, teachers reported spending extra time to accustom themselves to the online teaching environment, designing methods to engage with students and knowing individual students' comprehension of the teaching content (Scull et al. 2020). Furthermore, it became essential for teachers to provide psychological support for students who were at a higher risk of depression due to isolation from their teachers and colleagues (Scull et al. 2020). With COVID-19 outbreak, the aforementioned factors among others necessitated teachers to search for online resources to meet the need of the learners as well as organising virtual teaching-related activities inform of meeting and group discussion (Cavanaugh and DeWeese 2020). The existing literature on the impacts of COVID-19 on classroom teaching has predominantly focused on the difficulties faced by teachers during the process of transferring to online teaching, instead of teachers' psychological state, and mainly on the higher education sector. For instance, Besser et al. (2020) found a significantly higher level of stress among university teachers in Israel. In contrast, university teachers from China reported a high level of satisfaction towards different online teaching tasks, other than experimental classes (Wu and Li 2020). Teacher self-efficacy (TSE) has been described as a subjective indicator of the extent to which teachers can achieve specific tasks in the teaching profession and has been one of the most studied constructs in teacher education (Morris et al. 2017). To our knowledge, no study exists on TSE at school level during a pandemic, despite less experience of school teachers with online teaching and lack of commitment from the students (Murray et al. 2020). The present study investigates changes in teaching self-efficacy during the pandemic assessed by online TSE among school teachers in mainland China. It then looks at the moderation effects of two psychological constructs, namely adaptability and occupation burnout, on changes in online TSE.

2.2 Self-efficacy and teacher self-efficacy

From a social cognitive perspective, the construct of self-efficacy indicates human being's perception of their capability to complete foreseeable daily tasks, which shape their decision-making process. Highly efficacious individuals are more likely to set up more challenging goals, tend to be more resilient and experience fewer negative emotions in the process of achieving these goals (Bandura 1997). Much research has been done to investigate self-efficacy in various academic fields including the field of teacher education. Teacher self-efficacy plays an essential role in the choices of the teacher's personal goals, the extent of being persistent in the face of adversity and the strength of motivation to carry out certain behaviours in teaching such as use of digital teaching learning materials (Glackin and Hohenstein 2018; Van Acker et al. 2013). It was reported that teachers with higher TSE are more likely to feel engaged with students and experience more job satisfaction (Granziera and Perera 2019). They also tend to be more persistent with teaching adversities and try more creative strategies to

assist students to understand complex subject matters (Zee and Koomen 2016). It was further associated with retention of teachers at both preservice and in-service levels (McLennan et al. 2017). Similarly, higher teacher self-efficacy for educational technology standards affects the life long learning competencies of preservice teachers (Kan and Murat 2020).

Studies on TSE have been predominantly based on physical classroom teaching. Teachers' Sense of Efficacy Scale (TSES) (Tschannen-Moran and Woolfolk Hoy 2001) has been the most commonly used scale for TSE studies (Ma et al. 2019). This scale covers three aspects of classroom teaching, including instructional strategies, student engagement and classroom management. To cover more domains of the teaching profession, Skaalvik and Skaalvik (2007) validated a six-dimension scale, namely the Norwegian Teacher Self-efficacy Scale. This scale has six dimensions, namely, instruction, adapting education to individual students' needs, motivating students, keeping discipline, cooperating with colleagues and parents, and coping with changes and challenges. Efforts have been made to adapt a TSE scale with a stable factorial structure among PSTs. Pfitzner-Eden et al. (2014) refined the designs of TSES by changing the introductory wording, changing the response scale, and reselecting the items, and found a stable three-dimension structure among PSTs across both initial and last stages of ITEPs in Germany and New Zealand contexts. Similarly, researchers adapted TSES to measure TSE for teaching different subjects such as literacy skills (e.g., Tschannen-Moran and Johnson 2011) as to the domain specificity of self-efficacy (Bandura 1997). In other words, when one individual is self-efficacious at certain tasks, it does not mean that he or she is equally capable in all other tasks (Bandura 2019). However, the above approaches have only been demonstrated in classroom teaching as opposed to online teaching, mainly due to foundational differences between the two teaching contexts (DiPietro et al. 2008). This, therefore, necessitates the need for studies in the context of online TSE. Robinia (2008) adapt TSES into an online teaching context and found a validated two-factor structure, including TSE for online instruction and that for online technology, which has been considered as a well validated scale for online teaching (Corry and Stella 2018).

Teachers tend to feel less self-efficacious about online teaching as to the disparity between physical and online classroom environments (Johnson et al. 2020). It was identified that university teachers with prior experience in online teaching were more likely to report more motivation to teach online (Horvitz et al. 2015). In contrast, those without online teaching experience reported lower self-efficacy when they transformed into online teaching (Devica 2015). Among various reasons, anticipated difficulties with technology, losing connection with students, insufficient understanding of online pedagogical knowledge, and time-consuming features of online teaching were reported threatening online TSE. It is especially less controllable for teachers to engage students with low interests in studying online (Richter and Idleman 2017).

Online teaching self-efficacy could be developed, and different factors were reported being influential to its changes. TSE for online instruction of a cohort of teachers increased by completing an online teacher education course and their TSE for applying technology into online teaching and establishing online teaching environment was the most worrying (He 2014). Teachers feel less self-efficacious about interacting with students and providing feedback for their future students due to the concerns about not having opportunities to form connections with students (He 2014). Richter and Idleman

(2017) opined that TSE for online instruction increased with teachers spending more time on it whereas that for technology application remains a concern due to lack of technological support. Conversely, another study found the differences in technological techniques between the teachers and the students as a factor rather than technological support (He 2014). Accordingly, teachers with years of experience in online teaching reported supportive school administration as an essential factor influencing TSE for online instruction, while poor administration supports such as lack of regulations on students' behaviours leads to low TSE (Richter and Idleman 2017). Similarly, teaching small groups of students online boost the confidence of teachers as compared to teaching a large number of students (Devica 2015).

With COVID-19 adding to the existing challenges of TSE, the need for research in this field cannot be overemphasised. To our knowledge, this is the first study to investigate teachers' online TSE in the context of COVID-19.

2.3 Adaptability and teacher self-efficacy

One of the impacts of COVID-19 in the educational sector is the requirement for teachers to adapt to the online teaching environment. Adaptability as a construct was reported by Martin et al. (2012) to indicate the capability of individuals to cope with new changes and uncertainties through adjusting their psycho-behavioural mechanism. Adaptability has been proposed to include three dimensions, namely behaviour adjustment, emotional adaptation, and shift in attitude (Collie et al. 2018). This construct differs from teachers' resilience, with the latter indicating teachers' persistence in the presence of negative situations. Adaptability on the other hand goes beyond negative challenges and focus on situations that are not anticipated.

Recent evidence indicated that teachers' adaptability significantly impacts students' academic performance (Collie and Martin 2017). Similarly, among a few constructs, including TSE, teachers' adaptability and perceived autonomy assistance, adaptability was the only construct found to affect teachers' behaviours through encouraging students' creativity (Loughland and Alonzo 2018). What seems to be essential to teacher education practice is schools could potentially increase teachers' adaptability (Kudinova and Arzhadeeva 2020), and consequently TSE (Collie et al. 2020). Martin et al. (2013) opined that teachers' adaptability could be improved by guiding teachers to realise the necessities to adapt to instabilities as well as encouraging improvements towards their behaviours, cognitive and emotional states. Further research is needed to understand the impact of teachers' adaptability in teaching and teacher education (Collie and Martin 2017).

2.4 Teacher burnout and teacher self-efficacy

Burnout is usually accompanied by depression in the context of the work environment, which leads to emotional exhaustion, reduction in self-efficacy and lack of innovative attitudes/behaviours (Wang et al. 2003). Studies on burnout originated from human service workers whereby researchers used the term to indicate emotional exhaustion as well as low motivation and commitment (Freudenberger 1975). Burnout constitutes three main dimensions including exhaustion, cynicism and decreased professional efficacy, of which exhaustion is the core dimension (Maslach et al. 2001). Maslach

and colleagues developed a Maslach Burnout Inventory which became one of the most popular instruments to assess burnout (Maslach et al. 2001). It was identified that burnout has a significant correlation with job satisfaction, professional commitment and attrition (Maslach et al. 2001).

A number of studies have investigated the correlation between teacher burnout and teacher self-efficacy. Zee and Koomen (2016) examined 22 studies published between 1976 and 2014, and identified the correlation between these two constructs ranging from −0.17 to −0.63 (median of −0.25). Exploring into the relationship between TSE and the three dimensions of teacher burnout, the correlation between TSE and exhaustion ranges from −0.09 to −0.76 (median − 0.25), personal accomplishment ranges from 0.13 to 0.75 (median 0.36) and that of depersonalisation ranges from −0.16 to −0.6 (median − 0.33). Similarly, in a meta-analysis of 29 studies, Shoji et al. (2016) found an average correlation of −0.33 between teacher burnout and TSE. Accordingly, the mean correlation between TSE and the three dimensions of burnout were − 0.31, −0.33 and − 0.49 for exhaustion, depersonalisation and decreased personal accomplishment respectively. However, the reviewed studies were predominantly cross-sectional hence could have limitations in predicting the relationship between the constructs. Considering studies with repeated measures, Brouwers and Tomic (2000) found a significant correlation between TSE and teacher burnout measured at the same timepoint and a prior timepoint could predict the level of teacher burnout measured at a later timepoint. To further investigate the causal relationship between these two constructs, Kim and Buric (2019) measured both constructs repeatedly for three timepoints and found TSE could only predict disengagement at one timepoint. However, the study found the two dimensions of the teacher burnout, namely exhaustion and disengagement, could predict the level of TSE at a later timepoint.

2.5 Study aim

This study aims to apply a complementary mixed-method design (Creswell and Creswell 2017) to investigate the changes in online TSE at the beginning and end of online teaching during the COVID-19 school lockdown as well as its associated factors. Measurements were carried out to collect information on adaptability and teacher burnout to investigate their moderation effects on changes in online TSE.

3 Methods

3.1 Design

A retrospective survey using a mixed method approach was adopted. A mixed method study involves integration of a qualitative and quantitative data in a study, which improves the reliability of the study findings (Schifferdecker and Reed 2009). While majority of educational studies in Chinese context mainly adopt quantitative approach (Turnbull, Chugh and Luck 2020), this study adopted a mixed of quantitative and qualitative approaches to maximise the integrity of the findings. Firstly, it involves a set of three scales, each to assess participants online TSE, their adaptability and burnout, with a total of 34 items (Appendix 1). The last section of the questionnaire involved an

open-ended question to qualitatively elucidate challenges experienced by the participants during online teaching. Finally, a subset of the respondents who take part in the questionnaire survey were invited for an in-depth interview based on their responses, which enabled the triangulation of the data. Considering the nature of this research in Chinese context, no 'Institutional Review Board' approval was required. However, the participants were provided with an information sheet to read about the study and consent before the data collection. Similarly, no identifiable information was collected and the participants were assured of confidentiality of the data they provided.

3.2 Instruments

3.2.1 Teacher self-efficacy for online teaching

The present study used the Michigan Nurse Educators Sense of Efficacy for Online Teaching Survey (Robinia 2008). The scale has 32 questions including 24 items based on TSES and 8 extra items for technology application in online teaching to form a two-dimension structure. Both dimensions have high internal consistency with a Cronbach alpha of 0.97 and 0.86 respectively. In this present study, five items were chosen from each dimension to reduce the efforts of participants and they were instructed to rate the items using a prompt "please indicate how effective you think you are as a teacher in each of the following online teaching activities". Items for online instruction include "gauging student comprehension of what you have taught" and items for technology application in online teaching include "using asynchronous discussions (e.g., same time chat rooms) to maximise interaction between students in an online course". This gives a total of 10 items for this section. Participants were instructed to rate the items based on their judgement of online teaching capability at the beginning and end of online teaching during the COVID-19 school lockdown.

3.2.2 Adaptability

A 9-item Adaptability Scale developed by Martin et al. (2012) was adopted. It uses a 7-point response scale with 1 and 7 indicating the extent to which the respondents disagree or agree respectively. The scale covers contents of three dimensions including the frame of mind-set (e.g., I am able to think through a number of possible options to assist me in a new situation), behaviours (e.g., I am able to change the way I do things if necessary) and attitudes (e.g., to help me through new situations, I am able to draw on positive feelings and emotions). The scale was validated as a two-dimension structure among high school students, which include behaviour-cognitive adaptability and affective adaptability or a higher-order model that combines the two dimensions (Martin et al. 2012). Both dimensions have high internal consistency with Cronbach alpha being 0.87 and 0.76 (Martin et al. 2012).

3.2.3 Teacher burnout

A Job-Burnout Inventory for Secondary Teachers developed by Wang and colleagues was adopted (Wang et al. 2003). It has 28 items and uses a 7-point Likert response scale with 1 and 7 indicating the extent to which the respondents disagree or agree

respectively. Researchers validated a three-factor structure for burnout among Chinese secondary teachers (Wang et al. 2003), which include passion burnout ($\alpha = 0.886$), energy burnout ($\alpha = 0.857$) and professional self-effectiveness burnout ($\alpha = 0.652$). These three domains corresponded to exhaustion, cynicism and decreased professional efficacy in Maslach Burnout Inventory (Maslach et al. 2001). Passion burnout was reported to replace exhaustion to become a core dimension of burnout (Wang et al. 2003). In this present study, the top five items with the highest factor loadings were chosen to represent each dimension based on the Job-Burnout Inventory for Secondary Teachers developed (Wang et al. 2003). This gives a total of 15 items for this section.

3.3 Interview protocol

The interview was semi-structured and completed online. It was organised into four main sections. Firstly, the interviewees were asked to describe their online teaching experiences; secondly, they were instructed to reflect the extent to which they believe they were capable to effectively teach online at the initial stage of the online teaching and what aspects of online teaching activities they thought they could or could not complete at that time; thirdly, they were instructed to reflect what factors influenced their judgement; and fourthly, interviewees were asked to evaluate to what extent they could effectively teach online in the future if needed and why. All interviews were conducted in Chinese.

3.4 Translation of scales

Michigan Nurse Educators Sense of Efficacy for Online Teaching Survey and Adaptability Scale was originally in English and translated into Chinese based on the guidelines for scale translation suggested by Wild and colleagues (Wild et al. 2005). Two PhD candidates who could write and speak both Chinese and English sufficiently translated the English versions of the scales into Chinese. An experienced school teacher in China reviewed the two versions of translated scales and discussed with the first author to finalise the items for back-translation. A Chinese PhD candidate who was pursuing a degree in linguistics in Australia translated the Chinese versions back to English. The two versions of back-translated scales were sent to an experienced researcher who is a native English speaker to compare with the original scales. Chinese versions of scales for TSE and adaptability were finalised after adjusting for minor linguistic uncertainties. Burnout scale adopted was in Chinese language and hence it was used in its original form.

3.5 Data collection

Data collection for this study was conducted online. The instruments were first made available online and the responses were collected in August 2020 during the summer semester break. The online survey instrument involves five sections, which collected information about participants' demography, online TSE, adaptability, burnout and challenges experienced on the course of the online teaching respectively. The first section includes participants' demographic information such as gender, teaching grades and years of teaching experience at the beginning of the survey. The second section

enables the participants to retrospectively report their online TSE at the beginning and end of online teaching during the COVID-19 school lockdown during the first semester (February to July of 2020). This retrospective method could reduce the attrition between different time points and also increase the efficiency of data collection (Euser et al. 2009). The second and third sections respectively enable the participants to report their adaptability and level of burnout. The last section of the questionnaire enables the participants to report the challenges they faced during online teaching using the open-ended question "was there any challenge(s) you faced during online teaching? If so, what is/are the most challenging?"

One of the authors (YZ) utilised social media (Wechat) to post the link of the online survey together with a short description on its purpose, length of time needed to complete, and invitations for others to share the link through a snow-balling technique. This process was not suspended until there were no more participants replying to the survey within a two-week period. In line with the recommendation (Kline 2011), the minimum required sample size for a structural equation modelling including confirmatory factor analysis was 200. This number was exceeded in this study to account for incomplete responses.

3.6 Data analysis

The quantitative data was analysed using three methods. Firstly, a confirmatory factor analysis (CFA) was carried out in Amos 25 (Arbuckle 2017) to confirm the factorial structure of the scale for online TSE at both times and scales for adaptability and teacher burnout. Indexes of model fit including $\chi2/df$, comparative fit index (CFI), Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root means square residual (SRMR) were applied with $\chi2/df < 2$, CFI and TLI ≥ 0.95, RMSEA $\leq .08$, and SRMR $\leq .06$ identifying good models in line with previous literatures (Hooper et al. 2008; Hu & Bentler 1999).

Secondly, a two-step multilevel modelling was conducted in SPSS Version 22® (IBM Corp., Armonk, NY, USA) to investigate TSE changes. The first model used time as the only explanatory factor of the within-individual variation to check how TSE changed over time. This model was regarded as the baseline model. The second model included demographic variables as explanatory factors to adjust the initial difference in TSE levels attributable to the participants' background information. Both −2 times log-likelihood (−2LL) and Akaike's information criterion (AIC) were used to indicate model fits, with smaller values indicating better model fit. A significance of -2LL was tested based on the chi-square distribution (Field 2013; Heck et al. 2013) and a reduction of not less than 6 in AIC refers to a significant improvement in the model fit (Harrison et al. 2018). Results are reported based on the best-fit model.

Thirdly, the moderation effects of both adaptability and burnout on changes in TSE for online teaching were tested using PROCESS in SPSS. TSE scores at Time one and two were included as independent and dependent variables with adaptability and burnout being included as moderators separately.

Qualitative data from both open-ended questions and interviews were analysed in NVIVO using thematic analysis (Braun et al. 2016). The first author, being a native Chinese speaker, translated the qualitative responses into English. Initial familiarity with the data was done by the first author through listening to the recordings and

reading the transcripts repeatedly. Codes were initially generated using a reflective process of integrating insights emerging from the data and assigned to the corresponding themes. For instance, "According to the results of 'in classroom tests', we were only able to realise the students' understanding of the content was awful" was coded into the theme "*less satisfactory outcomes of the student studying*". The first two authors examined the codes and their corresponding themes systematically to ensure the trustworthiness of the analysis before reporting the results.

Considering the fact the study aims to examine change in online TSE as a whole, no sub-group analysis was conducted with respect to the demographic characteristics of the respondents.

4 Results

4.1 Quantitative data

4.1.1 Descriptive findings

A sample of 351 participants filled the online surveys (Table 1). Majority of the participants, 234 (66.7%) were female teachers, 156 (44.4%) were junior high school teachers and 143 (40.7%) were within the first five years of their teaching career. There were more subject teachers 211 (60.1%), compared to head teachers 140 (39.9%). About half, 137 (39%) were teaching in schools within cities,[1] whereas more than half, 192 (54.7%) were advanced school teachers.[2]

The description of mean, standard deviation, reliability, and correlation are shown in Table 2. TSE for online instruction and technology application correlates significantly with adaptability across two times of measurement with coefficient ranging between .518 and .552. Whereas the two TSE domains negatively correlated with two domains of burnout, namely passion burnout and reduced effectiveness with a correlation coefficient ranging between −.314 and −.125. No significant correlation was found between TSE and energy burnout.

4.1.2 Confirmatory factor analysis

The two-factor online TSE scale had good model fit at both times of measurement. For Time one, $\chi2/df = 2.90$, CFI = .977 and TLI = .969. RMSEA = .08, and SRMR = .046; For Time two, $\chi2/df = 3.06$, CFI = .977 and TLI = .968, RMSEA = .077, and SRMR = .0344. The model fit for adaptability scale was examined under one-factorial, two factorial, and a second-order factorial structures in line with the suggestion of using the scale as a one dimensional structure or multiple subdomain structure (Martin et al. 2012). The one-factor structure had good model fits; $\chi2/df = 2.80$, CFI = .987 and TLI = .982, RMSEA = .071 and SRMR = .0199 whereas the fit of RMSEA of both

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[1] Advanced schools have access to better educational resource and better teachers, compared with standard schools. (see Ma et al. 2019).
[2] In China, there are five levels of administrative divisionis, namely province, city, county, town and villages which are used to indicate the social economic status of the schools in each division (see Ma et al. 2019).

Table 1 Descriptive characteristics of participants ($n = 351$)

Variable	n	%
Gender		
Female	234	66.7
Male	117	33.3
Level of teaching		
Senior high	147	41.9
Junior high	156	44.4
Primary	42	12.0
N/A	**6**	**1.7**
Teaching experience		
15–20 years	100	28.5
10–15 years	49	14.0
5–10 years	59	16.8
0–5 years	143	40.7
Teacher's rank		
Headteacher	140	39.9
Subject teacher	211	60.1
Type of schools		
Advanced	192	54.7
Standard	159	45.3
Location of schools		
Rural	57	16.2
Town	78	22.2
County	77	21.9
City	137	39.0
N/A	**2**	**0.6**

N/A Not available

two-factor and second-order structures were larger than .080. For burnout scale, a three-factor structure received a good model fit, $\chi2/df = 2.94$, CFI = .965 and TLI = .956, RMSEA = .074 and SRMR = .0532 (Table 3).

4.1.3 Changes in online TSE

The model fit of TSE for technology application improved significantly in model 2, namely Δ AIC > 6 and Δ -2LL > 3.84 with one degree of freedom. The model fit of TSE for online instruction did not improve significantly (Δ AIC < 6 and Δ -2LL < 3.84). Significant individual differences were found in both TSE for technology application and online instruction at Time one ($p < 0.001$). With respect to change over time, TSE for technology application improved significantly at Time 2 ($\beta = .231$, $p < .001$) whereas that of online instruction did not significantly improve ($\beta = 0.014$, $p = .837$) (Table 4).

Table 2 Correlation coefficient between online teaching self-efficacy, adaptability and burnout

	Online instruction1	Online instruction2	Technology application1	Technology application2	Adaptability	Passion	Energy	Effectiveness
1 Online instruction1[a]	1							
2 Online instruction2[b]	.526**	1						
3 Technology application1[c]	.739**	.513**	1					
4 Technology application 2[b]	.548**	.761**	.651**	1				
5 Adaptability	.545**	.552**	.518**	.540**	1			
6 Passion burnout	−.125**	−.138**	−.140**	−.179**	−.193**	1		
7 Energy burnout	.095	.063	.037	.038	.129*	.551**	1	
8 Reduced effectiveness	−.265**	−.314**	−.227**	−.272**	−.388**	−.361**	−.087	1
Means	5.00	5.00	4.80	5.03	5.42	3.43	4.82	5.36
SD	1.256	1.245	1.289	1.317	1.582	1.713	1.137	1.051
Internal consistency	.927	.925	.907	.919	.775	.951	.753	.963

Note. [a] Online instruction1 indicates TSE for online instruction at Time one; [b] Online instruction2 indicates TSE for online instruction at Time two; [c] Technology application1 indicates TSE for technology application at Time one; [d] Technology application2 indicates TSE for technology application at Time two; $* p < 0.05$, $** p < 0.01$

Table 3 Model fits for confirmatory factor analysis

Models	χ2	df	p	χ2/df	CFI	TLI	RMSEA	SRMR
Online TSE Scale[a]								
Time 1	98.52	34	<.001	2.90	.977	.969	.073	.0346
Time 2	98.05	32	<.001	3.06	.977	.968	.077	.0344
Adaptability Scale								
One factorial structure	72.70	26	<.000	2.80	.987	.982	.071	.0199
Two factorial structure	90.56	26	<.000	3.48	.982	.974	.084	.0224
Second-order structure	90.07	26	<.000	3.46	.982	.974	.084	.0225
Teacher Burnout Scale								
Three factorial structure	182.52	62	<.001	2.94	.965	.956	.074	.0532

[a] The online TSE scale was measured at both Time one and two for online instruction and technology application

4.1.4 Moderation effects of adaptability and burnout

Adaptability significantly predicted TSE for both online instruction ($\beta = .33$, $p = .018$) and technology application ($\beta = .536$, $p = .001$) at time two. However, no moderation effects of adaptability were identified in the changes of the two TSE domains. Passion burnout significantly predicted TSE for online instruction ($\beta = -.437$, $p = .004$) at time two but not for technology application ($\beta = -.266$, $p = .147$). Reduced effectiveness did not significantly predict either TSE for online instruction ($\beta = -.198$, $p = .263$) or technology application ($\beta = -.271$, $p = .183$) at time two. The only significant moderating effect on changes in TSE was in passion burnout for online instruction ($\beta = .071$, $p = .019$) (Table 5).

4.2 Qualitative data

4.2.1 Open-ended question

Of the 182 participants who filled in the open-ended questions about the major challenge(s) they experienced during online teaching, various themes emerged (Table 6).

4.2.2 Interviews

Six of the participants (Table 7) were purposively selected for the interview based on their overall online TSE scores from the quantitative survey. Of these, three (Ji, Fang, and Xi) were among those that reported increase in TSE, whereas the other three (Huang, Ming, and Jian) were among those that reported having reduced their TSE.

Theme 1. Initial anxiety All interviewees ($n = 6$) felt challenged by the unprecedented online teaching transition, such as, feeling like turning into an internet celebrity. Lack of familiarisation with the online teaching technology was one main reason for the

Table 4 Model parameters and goodness of fit for multilevel modelling

Parameters	Online Instruction		Technology Applying	
	Model1	Model2	Model1	Model2
Fixed effects(is)				
Intercept	5.00**	5.474**	5.034**	5.628**
Time1	.003**	−.014	−.231**	−.231**
Time2				
Primary		.20		.82
Junior high		−.188		−.288
Senior high[a]				
1–5 years		−.210		−.139
5–10 years		−.10		−.282
10–15 years		.005		−.093
>15 years[b]				
Head teacher		−.08		−.156
Subject teacher[c]				
Key school		−.094		−.076
Standard school[d]				
Female		−.063		.046
Male[e]				
Village		−.181		−.175
Town		−.300		−.507*
County		−.386*		−.518*
City[f]				
Random effects				
Residual	.742**	.750**	.593**	.602**
Intercept	.822**	.830**	1.105**	1.07**
Model summary				
AIC	2202.308	2169.581	2180.071	2155.469
-2LL	2198.308	2165.581	2176.071	2151.469
Number of parameters	4	15	4	15

[abcdef] The parameter is redundant; * $p < 0.05$, ** $p < 0.01$

initial lower TSE. However, improvements in applying these technologies into online teaching such as video editing and using software including Tencent video, were commonly reported,

> I was very anxious at the beginning. It is because you never know who seat in front of you as parents of students or the whole family of a few generations could be there listening to you. … However, I got used to it with time elapsed. [Jian]

Table 5 Moderation effects of adaptability and burnout on the changes in two subdomains of TSE

Variable	β	SE	t	p	95%CI
TSE for online instruction					
Constant	.758	.745	1.017	.310	[−.708, 2.223]
Online instruction1[a]	.495	.175	2.825	.005	[.15, .839]
Adaptability	.33	.138	2.386	.018	[.058, .602]
Online insturction1*Adaptability	.004	.030	.141	.888	[−.0548, .0633]
Constant	3.319	.544	6.106	.000	[2.250, 4.388]
Online instruction1	.424	.105	4.019	.001	[.216, .631]
Passion	−.437	.152	−2.878	.004	[−.735, .138]
Online instruction1*Passion	.071	.03	2.365	.019	[.012, .13]
Constant	2.534	.552	4.593	.000	[1.449, 3.619]
Online instruction1	.618	.108	5.719	.000	[.405, .831]
Effectiveness	−.198	.177	−1.121	.263	[−.546, .15]
Online instruction1*Effectiveness	.006	.036	.171	.864	[−.065, .077]
TSE for technology application					
Constant	.528	.860	.614	.540	[−1.163, 2.219]
Technology1[b]	.419	.188	2.231	.026	[.050, .789]
Adaptability	.536	.165	3.250	.001	[.211, .860]
Technology1*Adaptability	−.019	.033	−.567	.571	[−.085, .047]
Constant	3.30	.645	5.117	.000	[2.032, 4.568]
Technology1	.389	.121	3.228	.001	[.152, .627]
Passion	−.266	.183	−1.455	.147	[−.626, .094]
Technology1*Passion	.038	.035	1.10	.272	[−.03, .106]
Constant	3.395	.644	5.271	.000	[2.128, 4.662]
Technology1	.448	.121	3.711	.000	[.211, .685]
Effectiveness	−.271	.203	−1.335	.183	[−.670, .128]
Technology1*Effectiveness	.0086	.040	.216	.829	[−.070, .087]

[a] Online instruction1 indicates self-efficacy for online instruction at Time one; [b] Technology1 indicates self-efficacy for technology application at Time two

Table 6 Emerging themes about challenges experienced in online teaching during COVID-19 ($n = 182$)

Themes	Exemplary quote
Technology ($n=60$)	"Not familiar with applying technology in online teaching"
Student supervision ($n=57$)	"It's difficult to supervise students in time"
Student management ($n=23$)	"How to control students' behaviour online?"
Studying outcome ($n=18$)	"The gap between students who are self-disciplinary and not was enlarged"
Engaging with students ($n=19$)	"It's easy for student to lose their attention"
Workload ($n=13$)	"Too much time spent on restructure the lesson online"

Table 7 Description of interviewees

Pseudonyms	Grade	Experience (years)	Head teacher	Subjects	Key school	School location	Gender	Δ online TSE[a]
Ji	Junior	5–10	Yes	English	Key	City	Female	0.6
Fang	Primary	5–10	Not	Chinese	Not	Town	Female	2.47
Xi	Junior	10–15	Not	History	Key	City	Female	0.7
Huang	Junior	5–10	Not	History	Key	City	Female	−1.7
Ming	Primary	4–5	Not	Mathematics	Key	City	Female	−0.3
Jian	Junior	3–4	Yes	Chinese	Key	City	Female	−0.5

[a] Δ Online TSE equals overall online TSE at Time two minus that at Time one

Theme 2. Issues caused by separations with students The participants ($n = 4$) reported that online teaching separated them from their students, which led to difficulties toward managing their misbehaviours and providing instant feedback. Teachers could not see the students and in some instances, they had to mute the students during the online instruction in order to control their noise. In some instances, students were reported to leave their account active while they were sleeping or even playing computer games. For instance, Ji, who worked as a headteacher felt frustrated because,

> As a headteacher, the whole class would normally quiet down once I stand in front of the classroom door as students fear their headteacher… but you always feel they are out of your control now. [Ji]

Teachers were unable to detect students' understanding instantly as they did in the physical classroom such as by looking at students' facial expression or asking questions randomly. Jian is a teacher of Chinese and reported,

> I could easily sense who did not understand the content in the regular classroom so I could provide the students with extra instruction. However, this process could not happen online so that you could not get students' understanding of foundational knowledge. So, you know you are teaching amazingly but you never know what states your students are in. [Jian]

The inability to provide supervision was also reported in students' in-classroom questioning and after-class homework. A disadvantage of using chatting windows to examine students' understanding was reported because students might copy the answers of others, resulting in identical answers of different students. Similarly, students were reported having submitted identical homework.

Theme 3. School administration The different experience of online teaching was reported across different schools ($n = 6$). Two primary teachers (Fang and Huang) reported not having done any teaching synchronously but recording and sending videos to students and checking on students' homework online. For instance, Huang teaches mathematics in a city primary school and regarded her school used a "free-ranging model". Teachers were simply told to choose teaching videos available online or record

her teaching clips for the students to watch. She was not aware of her students' understanding of the content and students failed to submit high-quality homework. In contrast, other interviewees ($n = 4$) were required to teach online according to the regular school schedule under the supervision of school administrators. Xi, a history teacher from a key junior middle school in her city reported her school administration of online teaching as being solid.

> The school had platform backstage to know how online teaching was like such as surveying the satisfaction of students about classroom teaching. The administrators would remind teachers once they found teachers were relying too much on playing online teaching videos and failing to keep their students engaged. [Xi]

Theme 4. Outcomes of the student studying Students' academic performance was commonly reported ($n = 6$) being unsatisfactory as to the tests taken after returning to the class. For instance, Huang found only two or three of her students (Grade 3) passed the knowledge tests taken after students returning to school. Jian also described,

> We enjoyed ourselves a lot in online teaching but we could not control students' academic performance. … All of my colleagues from all teaching subjects, realised students' studying quality was not good. So lack of constant supervision over students was the biggest issue. [Jian]

5 Discussion

This study explores the change in online TSE among teachers during COVID-19 school lockdown in China as well as its associated factors. Overall, the finding of the study indicates that TSE significantly improved for technological application compared to online instruction, which is majorly moderated by passion burnout. A major strength of these findings is being one of the few studies conducted in the context of online teaching during a pandemic. Similarly, the translated versions of the TSE and adaptability scales used can serve as an instrument for further research in the context of Chinese teachers during or outside pandemics like COVID-19.

A key fact from the findings of the study was the low online teaching self-efficacy at the beginning of the online teaching. This is a common phenomenon among practitioners where a lack of prior experience affect overall performance. This is in line with a previous study, which indicates teachers less/not self-efficacious about online teaching due to lack of relevant experience (Devica 2015). An alternate explanation for this could be that teachers were more likely to be threatened by the anticipated challenges in online teaching rather than lack of experience, considering the fact that they have not developed the required online pedagogies (Lee and Tsai 2010). With respect to the change in TSE, the two domains of online TSE (online instruction and technology application) differ, with the former not significantly improved. This outcome is not in line with prior finding in a higher education, which signifies more experience in online teaching tends to increase TSE for online instruction (Richter and Idleman 2017). On

the contrary, the finding supports the study of He (2014) that indicates TSE for building up of online teaching environment and interaction with students remains a key concern of teachers even after a short period of online teaching. On the other hand, the present study reported self-efficacy for technology application improved significantly, which support the finding (Lee and Tsai 2010) that indicates TSE for technology application increases with increases in online teaching experience. It appeared that technological challenges only tends (tend) to be influential before teachers familiarise themselves with the technologies (Lee and Tsai 2010; Shea 2019).

Exploring into the disparity in the changing patterns of the two subdomains of online TSE, namely online instruction and technology application, various factors might have played a role. Firstly, teachers reported to have used the same pedagogical methods they used in physical classroom teaching in the online teaching environment. This could be due to the reliance on traditional teaching pedagogies because of the necessity to build up a positive teacher-student relationship and engage students in online discussion (Bailey and Card 2009). Furthermore, the reliance on physical classroom pedagogies indicates the need for teachers to engage in online professional development courses (Richter and Idleman 2017), which could shape their perception of online teaching. Secondly, it could be due to the fact that teachers might not have developed sufficient positive online teaching experience as reported by Bandura (1997) that indicates mastery experience provides the most succinct information on individual evaluation abilities. Similarly, previous studies like Richter and Idleman (2017) in the higher education sector indicates significant increases in teachers' online TSE after carrying out online teaching because the characteristics of the students could influence the online TSE (Devica 2015). However, compared with the high levels of study autonomy in adult learning/higher education, teaching in schools might have more difficulties in engaging, managing and supervising students, leading to a reduced TSE (Reinders 2010). Another key factor that could affect change in teachers' online TSE in this study was unsatisfactory student academic performance with online teaching. In addition, teachers might have accumulated many successes in using technology by designing and completing online courses, which has been perceived as a distinctive aspect of online teaching (Robinia 2008). This is also in line with He (2014), who opined students' lack of technology capabilities in online teaching rather than application of online technology is a factor that lowered teachers' online TSE. Thirdly, online teaching models adopted by teachers differed across different school practice of online teaching. Two teachers interviewed in this study did not take any synchronous teaching as they expected but rather, arranged teaching videos and put it online for their students, compared with the other four interviewees who engaged in real time online teaching. This therefore indicates that the change in online TSE could differ based on the online teaching model adopted by a school.

Regarding the moderation effects, only one significant moderation effect was found in this study, which is the effect of passion burnout on the changes in TSE for online instruction. It identified that teachers with less passion burnout tend to report increases in online TSE. This could be associated with the fact that teachers in Chinese contexts tend to rely more on their passion towards teaching in stressful teaching situations in comparison to teachers from western cultural backgrounds, who tend to keep a positive image of being a capable teacher (Wang et al. 2003). In addition, the current study established a positive correlation between TSE and adaptability into online teaching

context. Furthermore, adaptability was a predictor of the level of online TSE in line with a previous study (Collie et al. 2020). However, no significant moderation effects of adaptability were found in changes of TSE for online instruction. It implies that teachers with better adaptability were more likely to feel better about online teaching but do not necessarily experience increases in their online TSE. Similar negative correlations were found between TSE and two subdomains of teacher burnout (Zee and Koomen 2016). However, no significant correlation was found between either subdomain of online TSE and energy burnout. This further supports the study of Wang, Liu and Wu (2003) that indicates a weak correlation between TSE and energy burnout compared to TSE and the other burnout subdomains. This could be associated with teachers becoming less energetic with the bulk of daily teaching tasks but maintain their high TSE by referring to their achievements in teaching (Dicke et al. 2018).

5.1 Limitations

Despite the strengths and contributions of these findings, certain limitations exist. Firstly, recall bias might have affected the participant's response due to the retrospective nature of the study. This is thought to be necessary considering the sudden pressure mounted on the teachers to transform to online teaching coupled with social/physical impact of the pandemic that could make collecting data at different times difficult. Secondly, the participants were not randomly selected across the study area. Instead, they were recruited through online and snowballing technique, and hence might not be a representative of the population. This method was adopted to ensure as many participants as possible were recruited for the study. Thirdly, the different models of online teaching employed by the participants' school/province might be not comparable and hence are likely to compound their report of TSE. For instance, schools who adopted a real-time online teaching model might have different teaching experience than those who send recordings of teaching to the students inform videos. This is considered a technical challenge that is beyond the control of the researchers. Fourthly, the adaptability scale used in the study is not domain-specific i.e. not meant for teaching, and hence might be less reliable in assessing teachers' adaptability to online teaching. Finally, the findings reported were general with no sub-group differences. This is so as the aim of the research was to examine the change in overall online TSE. Nevertheless, this study contributes to the body of literature by providing initial evidence on online TSE among school teachers, particularly during a pandemic.

6 Conclusion

Based on the findings of this study, it was concluded that teachers' online TSE for technology application increased among Chinese teachers during COVID-19 school lockdown. While both adaptability and teacher burnout can affect TSE, only passion burnout plays a significant role in the change of online TSE. Accordingly, various factors, which include lack of experience in online teaching, prior worries, separation of teachers with students, school administrative processes and unsatisfactory student academic performance were identified as the major associated factors affecting the teachers' online TSE.

Overall, there are implications of these findings for practice of online teaching in educational contexts. To begin with, the need to build teachers' capabilities for online teaching cannot be overemphasized, considering the advances in information and communication technology of the twenty-first century. Both students and teachers should be equipped with technological skills necessary to cope with unexpected change due to crises/disasters such as COVID-19. Similarly, online teaching pedagogies should be incorporated into regular mandatory teacher professional development programs to provide teachers with ongoing skills in online teaching. Furthermore, a mechanism should be developed to manage student behaviours on the course of online teaching as well as effectively supervising the students to evaluate their understanding.

Declarations

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