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ORIGINAL RESEARCH

Teacher Satisfaction in Online Education: A Two-Factor Model of Extrinsic and Intrinsic Factors Across Diverse Contexts

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Abstract
Blended learning modes are becoming the norm in educational institutions. This research investigates the factors affecting teacher satisfaction with online lesson delivery. This study was undertaken in primary, secondary, and higher education institutions across ten countries worldwide. A total of 247 teachers responded to the survey. This work innovatively validates a two-factor model of teacher satisfaction with online teaching, grounded in Herzberg's two-factor theory. A first-order confirmatory factor analysis (CFA) was used to validate the constructs, followed by a second-order exploratory factor analysis (EFA) to identify key drivers of teacher satisfaction. The results showed that there were two key hidden drivers of teacher satisfaction i.e., intrinsic factor and extrinsic factor. The two factors explained 75% of the variance in teacher satisfaction. Teachers reported higher satisfaction due to the flexibility and work-life balance that online teaching affords, while dissatisfaction stemmed from institutional policies and insufficient incentives. It was observed that STEM teachers and older educators had lower satisfaction and higher technology anxiety. These insights have potential applications beyond online teaching, extending to teacher satisfaction in physical classroom settings.

Keywords Teacher satisfaction · Online teaching · Blended learning · Factor analysis · Herzberg's two-factor theory

1 Introduction

Blended learning has become an integral part of our education system (Istenič, 2024). It refers to the integration of face-to-face learning in classroom and online learning / computer-mediated learning (Garrison & Kanuka, 2004; Graham, 2006). Online learning overlaps with the general category of distance education, which began in the 1700s and evolved from correspondence (e.g. printed texts) to visual-auditory (e.g. one-way video, Television), ultimately leading to ICT-based learning (e.g. Internet-based learning) (Bozkurt, 2019; Means et al., 2013). This contemporary form of online learning differs significantly from previous distance education methods, offering convenient, personalized learning with improved

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quality at lower costs (Becker et al., 2017; Taylor, 2001). Furthermore, the integration of Artificial Intelligence (AI) in education is expected to drive rapid advancements, further transforming the landscape of blended learning (Woollaston et al., 2024).

Blended learning offers numerous benefits for both students and teachers. It offers flexibility in accommodating online and in-person learning and enhances learning outcomes (Baepler et al., 2014; Bernard et al., 2014). A meta-analysis indicates that blended learning surpasses face-to-face learning by approximately one third of a standard deviation in student performance (Bernard et al., 2014), and research shows that it can reduce classroom time by 30–79% without compromising learning achievements (Müller & Mildenberger, 2021). Additionally, blended learning fosters authentic learning environments, enabling students to engage with real-world contexts in the classroom (Istenič, 2021). It also promotes collaborative learning, which enhances social skills, openness to diversity and creative thinking (Becker et al., 2017). Importantly, it develops students' digital literacy, a critical 21st-century skill (European Commission Directorate-General for Education, 2022; Partnership for 21st Century Skills, 2019), and contributes to educators' digital knowledge and capacity (Koehler & Mishra, 2009). Furthermore, the integration of artificial intelligence and learning analytics in blended learning provides personalized feedback, particularly in formative assessments (Becker et al., 2017; Spector et al., 2016). Overall, blended learning not only improves educational outcomes but also cultivates essential skills and knowledge that prepare students for future challenges.

There are various classifications of blended learning. Staker and Horn (2012) identify four models: the rotation model, where students alternate between online and in-person activities on a fixed schedule; the flex model, which allows students to switch modalities at their own pace with available in-person support; the self-blend model, where students supplement traditional courses with online options; and the enriched-virtual model, characterized by predominantly online instruction complemented by some face-to-face interaction. Bates (2022) proposes a continuum of digital learning, positioning blended learning between face-to-face and fully online delivery. Within this continuum, various delivery modes emerge including face-to-face instruction integrated with learning management systems; flipped classrooms utilizing lecture capture; alternating semesters of in-person and online learning; hybrid models where online learning predominates; and hyflex learning that allows students to choose their preferred modality. These models vary in flexibility, personalization, and student autonomy.

In educational design, Istenič (2024) proposed a comprehensive model that integrates several key elements, including learning environment affordance, which ranges from integrated face-to-face classrooms to distributed remote learning; time, encompassing synchronous real-time activities, asynchronous activities, and bichronous activities that combine both formats (Martin et al., 2023); modality, distinguishing between co-located and dislocated learning environments; interactivity methods, which include individual work, group work, and teacher-led instruction; and medium, considering various formats such as speech, text, audio, video, and multimodal approaches.

However, the blended mode of teaching and learning has unique advantages and challenges such as the technique barriers and teachers' attitude (Banihashem et al., 2023; Rasheed et al., 2020). Therefore, it is crucial to examine the efficacy, challenges, and satisfaction in online teaching context to ensure educators receive the necessary support, and that teaching

practices are optimized. Additionally, understanding and enhancing teacher satisfaction in online settings is essential for leveraging technology to improve learning outcomes.

The satisfaction of faculties was considered one of the five quality pillars in online education (Moore, 2005), yet it has attained less attention compared to student perspectives. Though issues surrounding the satisfaction of learners and teachers are common in online education, the focus has predominantly been on students. Numerous studies have explored factors affecting student motivation, acceptance, engagement, and performance (Anthony Jnr, 2024; Boerchi et al., 2023; Bozan et al., 2023; Carrasco-Hernández et al., 2023; Hejazi et al., 2023; Hughes-Roberts et al., 2023; Squire, 2023; Sunday et al., 2022; Yildiz Durak et al., 2024; Yu & Zadorozhnyy, 2023). In contrast, instructor satisfaction remains underresearched (Baruth & Cohen, 2023; Guo & Li, 2023; Tawfik et al., 2024; Xiao et al., 2023). Increased teacher satisfaction could lead to higher level of work engagement and performance (Antoniou et al., 2023), and teachers' effective use of technology positively influences students' perception and motivation (Simon et al., 2024). Therefore, greater emphasis needs to be placed on teachers' perspectives in the context of online teaching.

1.1 Teacher Satisfaction Indicators

The volume and complexity of indicators for teacher satisfaction make it difficult to accurately categorize the factors, leading to inconsistency in classification. As a result, most research tends to focus on one or more specific indicators of teacher satisfaction within a given context. For instance, a study identified four factors that influence faculty satisfaction: teacher-student interaction, teacher and IT-related aspects (e.g., technical expertise and support), teacher training, and teacher preparedness (Joshi et al., 2022).

A substantial amount of research examines the impact of institutional support and provisions. Support from institutions such as technology training was found to be the most prominent indicator for teacher satisfaction and teaching quality (Saeed et al., 2021). Teachers have highlighted the importance of training and digital literacy, expressing a need for technology support and professional training related to online teaching (Joshi et al., 2022; Li & Yu, 2022). Additionally, IT facilities and related policies in institutions prove effective in reducing teacher burnout in online teaching (Chen et al., 2022). Despite the demand for training and support, a lack of these resources continues to hinder the effectiveness of online teaching in some institutions (Simon et al., 2024). Surveys among 202 management members and 1739 teachers in Switzerland revealed that teachers perceive lower levels of institutional support compared to school management teams (Rauseo et al., 2022).

Teachers' self-efficacy is also a critical indicator for satisfaction. Technological self-efficacy affects teachers' perceptions of success in online learning (Masry-Herzallah, 2023). Similarly, Zhu et al. (2022) found that secondary school teachers' satisfaction was positively related to the selectivity and suitability of online learning resources, as well as their technological and online teaching self-efficacy. Similarly, Teachers' pedagogical and online communication readiness (perception of their ability to teach online) were found to have a significant and positive correlation with teacher satisfaction and confidence (Lim, 2022; Rauseo et al., 2022; Simon et al., 2024). In some studies, teacher self-efficacy proved the most prominent predictor of satisfaction, surpassing even the perceived usefulness and ease of use of the technology (Falah Alfalahat, 2021). In addition to self-efficacy, teacher perceptions of online teaching and interactions have been examined. For example, a study con-

ducted at a U.S. university found that teachers held a positive perception of online teaching, viewing it as useful and finding the technology easy to use (Zhu & Zhang, 2022). Other indicators, such as interaction, also significantly affect teacher satisfaction (Masry-Herzallah, 2023). For instance, teacher on-slide presence promotes expressiveness and slide-content interaction, which results in a significant improvement in perceived knowledge gain, student engagement, and teacher satisfaction (Katai & Iclanzan, 2022).

1.2 Teacher Satisfaction Models

To encompass specific indicators for teacher satisfaction, several models have been proposed to create a comprehensive framework. Table 1 provides a summary of these models, highlighting the key constructs they address. Numerous studies have used the Technology Acceptance Model (TAM): the TAM has 13, 344 citations and the TAM 3 has 10,456 cita-

Table 1 Summary of teacher satisfaction models from existing literature

Models	Key Constructs	Definitions
Technology Acceptance Model (TAM) (Davis, 1989)	Perceived Usefulness	"the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320).
	Perceived Ease of Use	"the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320).
	Subjective Norm	Included in an extension of TAM (TAM 2) only. Adapted from the Theory of Reasoned Action (TRA). "the person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Fishbein & Ajzen, 1975, p. 302).
The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003)	Performance Expectancy	"the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh et al., 2003, p. 447).
	Effort Expectancy	"the degree of ease associated with the use of the system" (Venkatesh et al., 2003, p. 450).
	Social Influence	"the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003, p. 451).
	Facilitating Conditions	"the degree to which an individual believes that an organisational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003, p. 453).
Herzberg's Two-Factor Theory (Herzberg, 1987)	Motivator	"the growth or motivator factors that are intrinsic to the job are: achievement, recognition for achievement, the work itself, responsibility, and growth or advancement" (Herzberg, 1987, p. 9).
	Hygiene	"hygiene factors that are extrinsic to the job include: company policy and administration, supervision, interpersonal relationships, working conditions, salary, status, and security" (Herzberg, 1987, p. 9).
E-Learning Three-Category Model (Cheok & Wong, 2015) Adapted from Information System Success Model (DeLone & McLean, 1992)	User-Related Factors	Include "anxiety, attitude and self-efficacy" (Cheok & Wong, 2015, p. 80).
	Organisation-Related Factors	Include "training, technical and management support" (Cheok & Wong, 2015, p. 80).
	System-Related Factors	Include "perceived ease of use, perceived usefulness, accuracy and interaction" (Cheok & Wong, 2015, p. 80).

tions in Google Scholar. Figure 1 shows the evolution of this model. There are also adaptions and extensions of the Technology Acceptance Model (Falah Alfalahat, 2021; Nikou & Economides, 2019; Persico et al., 2014). Technology Acceptance Model has evolved into the more robust Unified Theory of Acceptance and Use of Technology (UTAUT), after Venkatesh et al. (2003) reviewed and synthesised eight different acceptance models. UTAUT showed more power in explaining the teacher satisfaction and was widely used by researchers (Ifenthaler & Schweinbenz, 2013).

Many other studies have attempted to classify teacher satisfaction indicators. Cheok and Wong (2015) (in Table 1) reviewed various theories and proposed a categorisation: user-related factors (anxiety, attitude, and self-efficacy), the organisational-related factors (training, technical and management support), and the system-related factors (perceived ease of use, perceived usefulness, accuracy, and interaction). In addition, interviews with educators at universities identify three aspects that affect online teaching experience: personal qualities (e.g., personalities, acceptance of online teaching), pedagogical beliefs (e.g., perceived usefulness of online teaching, educators' role in online teaching), and macro and institutional factors (e.g., support and resources available, workload) (McCarthy et al., 2021). However, those classifications were theoretical and lacked validation through quantitative analysis.

To create a faculty satisfaction model, some research has drawn upon theories from other fields. One theory is Herzberg's two-factor theory on job satisfaction (Herzberg, 2008): the motivation factor and the hygiene factor. The motivator factor refers to elements intrinsic

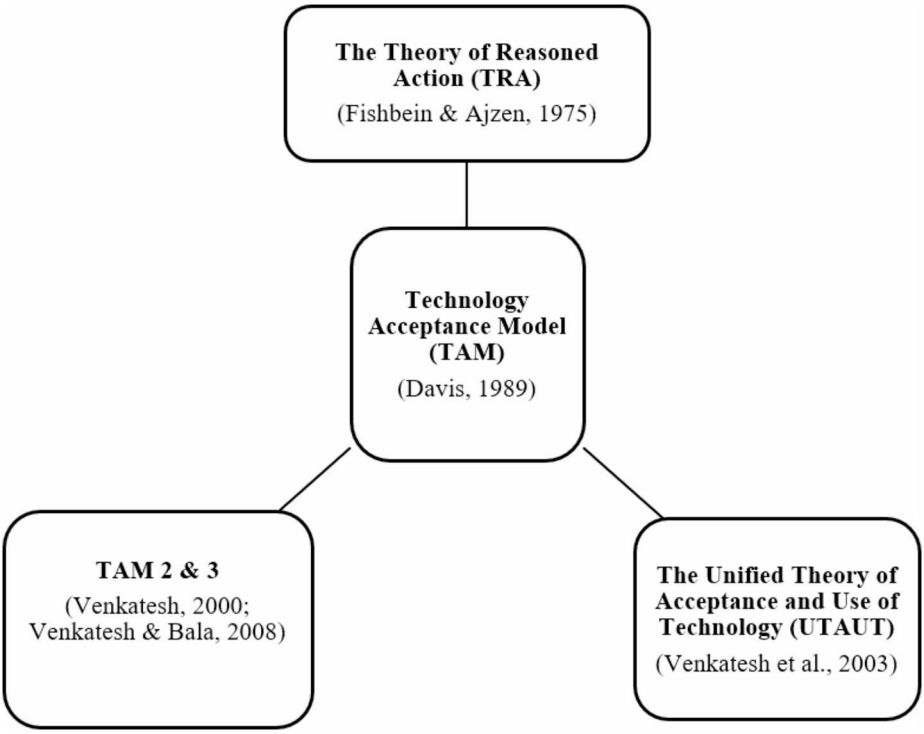

Fig. 1 Evolution of Technology Acceptance Models, adapted from Rondan-Cataluña et al. (2015)

to the job content, such as achievement and employee personal growth. The hygiene factor refers to variables extrinsic to the job, such as policy, administration, salary and working environment. This two-factor theory has served as a conceptual framework in various studies, such as a qualitative investigation into the job satisfaction of Non-Tenure-Track Faculty, though not specifically in the context of online teaching (Waltman et al., 2016), and in a quantitative study focused on higher education within the online teaching environment (Marasi et al., 2022). However, the two-factor theory was used in the studies as theoretical framework, and none has provided evidence to validate the two-factor model. One study attempted to validate the model by exploring the interrelationship among hygiene, motivator, and teacher satisfaction based on a sample from Malaysia and Indonesia, and the results show that motivators mediates hygiene's effect on satisfaction, meaning that motivation multiplies the hygiene factor's effect on satisfaction (Basbeth et al., 2021). However, the research did not demonstrate that the driving forces of teacher satisfaction could be divided into motivators and hygiene factors.

1.3 Novelty and Research Questions

The majority of existing research explores the contribution of individual factors and the interplay among them, highlighting the need for clear and consistent models and frameworks that encompass diverse factors. A more structured approach is essential to categorize these factors using a simple and effective model. Two primary approaches have emerged in this area: one grounded in technology acceptance, which emphasizes the role of technology, and the other based on job satisfaction, which focuses on motivation (see Table 1).

In this work, the advantage of the two-factor job satisfaction theory lies in its simplicity, as it categorizes variables into two factors: intrinsic and extrinsic. While technology acceptance models (focusing on ease of use and usefulness) are widely adopted to explain teacher or learner satisfaction with online teaching, job satisfaction theories have been less frequently applied. Despite the effectiveness of the two-factor job satisfaction theory in explaining online teaching satisfaction, there is a lack of evidence supporting its use, particularly outside the context of higher education.

This study aims to validate the two-factor model by applying it to a range of educational contexts—primary, secondary, and higher education—across various countries. Despite the rapid growth in online education research, there is a greater focus on student satisfaction, particularly among undergraduates, while teachers' perspectives require more attention (Baruth & Cohen, 2023; Guo & Li, 2023; Tawfik et al., 2024; Xiao et al., 2023). Additionally, the research tends to prioritize STEM subjects over non-STEM, and tertiary education over pre-tertiary levels (Tawfik et al., 2024). Quantitative questionnaires as the predominant instruments in this field remain inconsistent (Tawfik et al., 2024).

This study innovatively confirms that two primary drivers—intrinsic and extrinsic factors—underlie teaching satisfaction within online learning contexts across both pre-tertiary and higher education, as well as STEM and non-STEM subjects. Unlike most studies that focus on a single institution or context with a greater emphasis on higher education, this research provides evidence from various schools and universities across Asia, Africa, and Europe from teachers' perspectives.

Focusing on education as a whole (including primary, secondary, and higher education) and covering participants from 10 countries across Asia, Africa, and Europe, this research

investigates whether teachers from schools and universities are satisfied with online teaching and what underlying factors influence their satisfaction. It organizes complex indicators into a two-factor model, then exploring specific indicators within this framework. Finally, potential interventions will be suggested to enhance teachers' satisfaction and motivate them for better performance.

Research questions:

1) How satisfied are teachers with online teaching in various aspects?.
2) Is teacher satisfaction driven by a single factor or multiple factors?.
3) How does teacher satisfaction correlate with demographic information such as age and subject taught?.

2 Methods

2.1 Participants and Procedure

This work used social and private networks to distribute the questionnaires. A total of 247 teacher participants, from pre-tertiary to higher education levels, were involved in this study, representing ten countries: China, Malaysia, the United Arab Emirates, Togo, Ethiopia, France, the UK, Poland, Russia, and Ukraine. The majority of participants were from Asia, particularly China, which provided valuable insights. This allowed for obtaining a good contrast between respondents from developed countries (e.g., France, the UK, Poland) and least developed countries (e.g., Togo, Ethiopia) offering unique perspectives that enriched the overall findings of the research. This diversity is particularly valuable given the limited research in developing countries (Bond et al., 2020). All respondents of this survey had taught at least one course entirely online in the previous year. The questionnaire on JISC survey platform was sent to two teachers in Shandong province of China and a professor in the UK to help spread via social media, reaching approximately 500 people in 10 countries around the globe. The study achieved a response rate of 50%. The purposive and snowball sampling were employed to select participants for this research (Parker et al., 2019; Tongco, 2007). Initially, purposive sampling was used to identify key teachers who were well-suited to the research objectives and could provide valuable insights. Institutions from primary to higher education, teachers from STEM and non-STEM subjects, and countries with diverse socio-economic contexts were deliberately chosen. That could minimise bias and endure a broader representation. Following this, snowball sampling was adopted by asking the initial respondents to share the survey with teachers who met the study's criteria, allowing for a larger and more representative sample. The combination of purposive and snowball sampling facilitated the collection of extensive and representative perspectives aligned with the research questions. No incentives were provided for participation in the survey. There are no missing data, as completeness checks were performed by the survey platform before the questionnaire was submitted.

2.2 Instrument Development

When designing the questionnaire, items were adapted from three validated surveys on teacher satisfaction with online teaching (Bolliger et al., 2014; Marasi et al., 2022; Stickney et al., 2019). These surveys have been widely recognized for their reliability and validity in assessing various dimensions of teacher satisfaction in online education. All the satisfaction-related items were measured using a 5-point Likert scale (1 representing "strongly disagree", 5 representing "strongly agree"). Demographic information was also collected, such as age, gender, educational background, and the amount of experience with online learning / teaching.

Before administering the final survey, a pilot study was conducted with a smaller group of educators to test the clarity and effectiveness of the questionnaire. Feedback from this pilot study led to revisions, ensuring that the questions were both relevant and easy to understand. Additionally, the questionnaire was reviewed and refined in consultation with experts in education and online learning, further enhancing its validity and reliability.

2.3 Data Analysis

Several steps were undertaken during this study and Fig. 2 displays the process of the current research.

Data analysis was done with SPSS 29 and Mplus 8. SPSS 29 was used for descriptives, linear model and second-order exploratory factor analysis. Mplus 8 was used for the first-order confirmatory factor analysis (CFA). Using Mplus 8, a first-order confirmatory

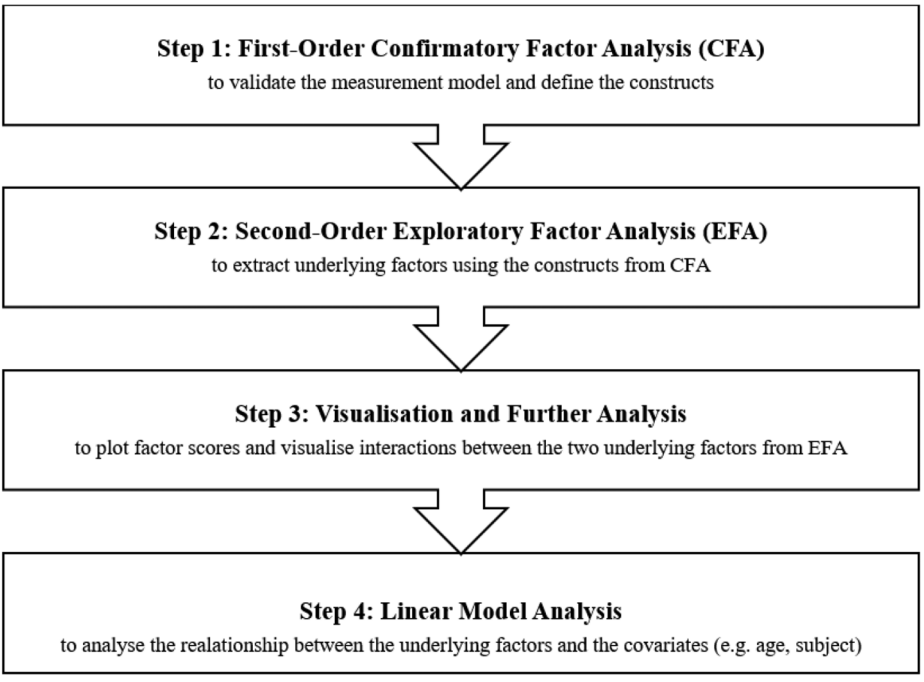

Fig. 2 Procedures of the current research

factor analysis (CFA) was conducted to 26 variables to validate the measurement model and determine how the observed variables relate to their underlying latent constructs. Confirmatory Factor Analysis (CFA) is used to test whether the data fit a hypothesized measurement model. This step ensured that the constructs were appropriately defined and that the model fit the data well. Eight constructs (e.g. self-efficacy, interaction) were identified for further analysis. The model fit shows a good result (RMSEA = 0.06, CFI = 0.99, TLI = 0.99, SRMR = 0.02). All factor loadings are significant ($p < 0.001$) and over 0.5, exceeding the threshold of 0.4. Figure 3 showed that eight constructs were identified, i.e., Student (stu1, 2, 3, 4), Efficacy (effi1, 2, 3, 4, 5), Perception (per1, 2), Anxiety (anx1, 2), Interaction (int1, 2, 3), Training (t1, 2, 3), Provisions (supp, pol, incen), and Balance (bal, flex, use2, use1).

Following the CFA, a second-order exploratory factor analysis (EFA) was conducted using SPSS 29 with principal axis factoring and an oblique rotation method (Direct Oblimin). This analysis aimed to uncover the underlying factors that drive teacher satisfaction behind the 8 constructs. EFA is used when there is not a hypothesis about the underlying structure of the data. The EFA identified two primary factors: internal and external drivers of satisfaction. A correlation analysis was performed between these two factors and overall satisfaction. The pairwise correlations (Spearman's rank correlation coefficient) among all constructs were calculated. Spearman correlation was chosen because it is a non-parametric measure for bivariate relationships between variables, suitable for non-normally distributed data.

Following the factor analysis, the factor scores were scrutinised in a scatter plot, i.e., internal factor versus external factor. A linear model of the two factors versus the covariates was used, to investigate how different variables such as age and subject influence online teaching satisfaction.

Table 2 shows the definition and summary statistics of the eight constructs, which include two to five items. Cronbach's alpha test was used to measure the reliability of each likert scale (Field, 2018). Seven likert scales demonstrated a commendable level of reliability ($\alpha \geq 0.92$) and anxiety has a lower but acceptable reliability ($\alpha = 0.738$). Although the reliability score for anxiety is below the preferred threshold of 0.80, it still demonstrates acceptable reliability (Cortina, 1993). This score may reflect the limited number of items or cultural differences in the sample affecting anxiety experiences. Given its significance in the study,

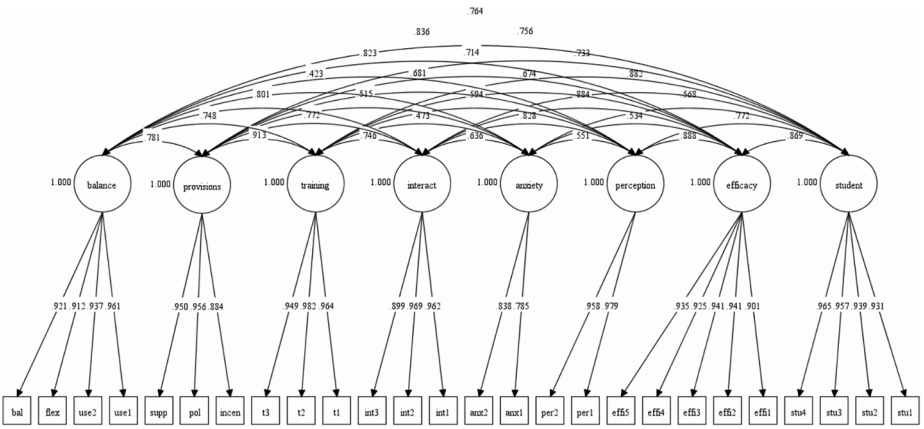

Fig. 3 A first-order confirmatory factor analysis to 26 variables (standardized estimates are shown)

Table 2 Definitions and summary statistics of constructs ($N=247$)

Variables	Definition	Number of items	Cronbach's α
Student	Teachers' satisfaction with student motivation, engagement, and academic performance.	4	0.953
Efficacy	Teachers' self-confidence in choosing teaching materials, designing lessons, giving assignments and facilitating online interactions.	5	0.951
Perception	How teachers view the effectiveness and ease of use of the online teaching platform.	2	0.946
Interaction	Teachers' satisfaction on interactions between students themselves, teachers themselves and between students and teachers.	3	0.940
Training	Teachers' satisfaction on institutions' training about online learning, the teaching platform and other relative technology.	3	0.960
Provisions	Teachers' satisfaction on the institution about incentives, policy and technology support during online learning.	3	0.920
Balance	Teachers' satisfaction on the flexibility and work-life balance during online learning.	4	0.939
Anxiety	Teachers' anxiety and fear about using the online teaching system.	2	0.738

this variable is retained for analysis, as it offers valuable insights. Student, i.e., the satisfaction with students refers to how well teachers' expectations towards students' behaviour and performance are met. Self-efficacy refers to teachers' belief in their ability to design, deliver, assign, and assess online courses. Perception refers to how teachers evaluate online teaching platforms in terms of its effectiveness and ease of use. Interaction refers to teachers' satisfaction with the frequency and quality of the interactions among teachers, students, and peers. Training refers to whether teachers believe their institution offers adequate and appropriate tutorials about online teaching in general and the specific platform they are using. Provisions refer to teachers' satisfaction with the incentives during online teaching, the policy and regulations, and technology support they received from the institution. Balance includes flexibility in schedule and their work-life balance. Anxiety refers to how anxious teachers are about using the teaching platform and how they panic when problems arise during online lessons. Based on the results of confirmatory factor analysis, eight variables were created by averaging the corresponding items.

3 Results

3.1 Descriptive Analysis – Research Question 1

The participants covered a wide range of ages, institutions, and educational backgrounds (Table 3). A total of 68.4% of the teacher participants are female and 31.6% are male. Participants who are 41–50 years old account for 44.9%, those no more than 40 years old make up 29.1% and those more than 50 years old account for 25.9%. In terms of institution, almost half (47.8%) of the participants teach in junior high schools, 17.4% in primary schools, 23.9% in senior high schools and 10.9% in universities. The majority (79.8%) of participants has a bachelor's degree, 7.3% have a master's degree, 8.5% have a doctorate degree, and 4.5% have received only teacher training. For subjects, more participants were from STEM fields (69.2%) than non-STEM fields (30.8%). On average, teacher participants have a teaching experience of 20.89 years (SD = 10.32) and taught online for approximately 9 months (SD = 7.62).

The descriptives in Table 4 give a summary of the central tendency (mean) and dispersion (standard deviation) of each variable. The efficacy (M = 3.75, SD = 1.10) and balance (M = 3.75, SD = 1.13) exhibit the highest score among the variables, However, the provisions score the lowest among the variables, with a mean of 3.00, and it shows the largest dispersion among all the variables, as denoted by a standard deviation of 1.40. Within the

Table 3 Sample characteristics of teachers (n = 247 teachers; M: mean; SD: standard deviation)

Characteristic	Sample Proportion (%)
Gender	
Female	68.4
Male	31.6
Age group (years)	
≤40	29.1
41–50	44.9
>50	25.9
Institution	
Primary	17.4
Junior high	47.8
Senior high	23.9
University	10.9
Education degree	
Teacher Training	4.5
Bachelor	79.8
Master	7.3
Doctorate	8.5
Subject	
STEM	69.2
Non-STEM	30.8
Teaching experience (years) M (SD)	20.89 (10.32)
Online teaching experience (months) M (SD)	9.21 (7.62)

Table 4 Means, standard deviations, and correlations (n = 247 teachers)

Variables	M	SD	1	2	3	4	5	6	7	8
1.Student	3.36	1.21	--							
2.Efficacy	3.75	1.10	0.829**	--						
3.Interaction	3.34	1.24	0.815**	0.823**	--					
4.Training	3.54	1.28	0.679**	0.645**	0.666**	--				
5.Provisions	3.00	1.40	0.685**	0.655**	0.679**	0.824**	--			
6.Balance	3.75	1.13	0.723**	0.775**	0.729**	0.699**	0.692**	--		
7.Perception	3.55	1.34	0.707**	0.820**	0.747**	0.534**	0.589**	0.744**	--	
8.Anxiety	3.02	1.24	0.417**	0.407**	0.484**	0.355**	0.373**	0.315**	0.405**	–

**Correlation is significant at the 0.01 level (2-tailed)

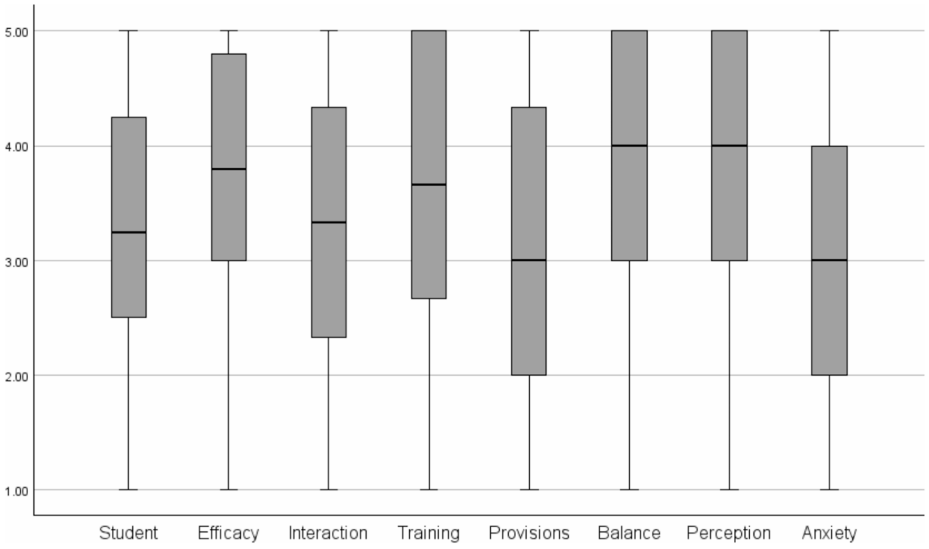

Fig. 4 Comparison of score distribution across 8 variables using boxplot analysis

provisions scale, incentives have a mean score of 2.63 with a standard deviation of 1.60. Similarly, policy has a mean of 3.08 and a standard deviation of 1.47.

Figure 4 depicts the overall data range and its distribution in terms of median and quartiles. The median values across the 8 variables exhibited a similar pattern with the mean statistics in Table 4. The provisions (including incentives, policy and technology support) featured lower scores than the other variables, while teachers' work-life balance, self-efficacy and perception of online teaching, were much higher. It was observed that the interquartile range of 50% of participants revealed an expanded span in 2 variables, that were, provisions and training. This means that there was no common practice among the surveyed institutions in terms of technical support, training, policy and incentives. The provisions variable in the boxplot revealed a negative skewness, with the median positioned closer to the lower quartile, indicating a concentration of lower values in the dataset. As provisions show the lowest mean among all variables (M = 3.00, SD = 1.40, Table 4), one of its indicators, incentives, was explored. Figure 5 shows the distribution of scores of incentives during

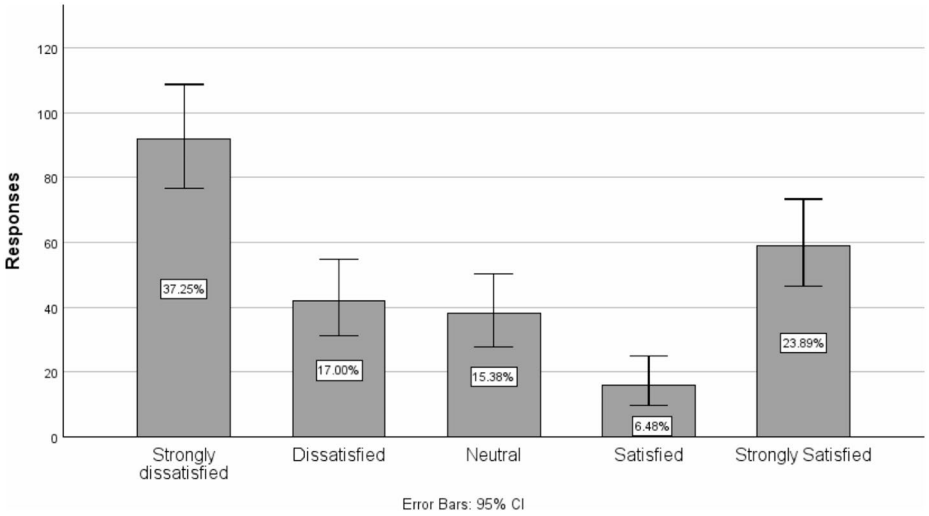

Fig. 5 Distribution of incentives scores

Table 5 Score distribution of incentives, technology support and policy

	Incentives	Tech Support	Policy
Strongly Dissatisfied	37.2%	14.6%	19.4%
Dissatisfied	17.0%	17.8%	19.0%
Neutral	15.4%	21.9%	22.7%
Satisfied	6.5%	15.4%	11.7%
Strongly Satisfied	23.9%	30.4%	27.1%
Total	100%	100%	100%

Table 6 Factor loadings after rotation (pattern matrix) and communalities of 7 variables

		Factor		
No.	Variables	1	2	h^2
1	Student	**0.687**	0.229	0.751
2	Self-efficacy	**0.984**	-0.070	0.875
3	Perception	**0.954**	-0.121	0.759
4	Interaction	**0.753**	0.172	0.782
5	Balance	**0.675**	0.217	0.712
6	Training	-0.023	**0.952**	0.875
7	Provisions	0.154	**0.766**	0.780
	α	0.974	0.952	

Note: Bold values represent factor loadings over 0.40

online teaching. More than half (54.25%) of the participants were dissatisfied with their incentives, while only 30.37% were satisfied.

Similarly, other indicators of provisions demonstrate low satisfaction. Table 5 below shows that 38.4% of participants were dissatisfied with the institution policy while 38.8% were satisfied. Similarly, 32.4% were dissatisfied with technology support provided by their institution, while 45.8% were satisfied. Policy and technology support showed slightly

higher satisfaction than that with the incentives. However, they were lower than all other variables, and considering participants tend to agree with the questionnaire items without showing openly their true opinions (Oppenheim, 1992), these aspects need attention from policy-makers.

The results presented in Table 4; Fig. 4 have several implications for further analysis and decision-making. The high mean scores for work-life balance and self-efficacy suggest that these aspects are well-regarded by the respondents. Organizations should recognise these positive perceptions and consider maintaining or enhancing policies that support flexible work arrangements and work-life balance initiatives. In addition, improving self-efficacy can enhance employees' confidence in their abilities to teach effectively. By doing so, they can potentially boost employee satisfaction, well-being, and overall productivity.

The results suggest that provisions such as incentives, institution policy, and technical support are potential areas that require attention and improvement. Addressing these areas could lead to increased satisfaction and engagement among employees. Organizations should consider conducting targeted interventions, such as comprehensive policy reviews, enhancing technical support systems, and salary benchmarking, to address concerns and create a more positive work environment. In this way, they can ensure that employees have the necessary resources and support to work effectively, thereby fostering a more motivated and productive workforce.

3.2 Identification of Underlaying Factors – Research Question 2

A second-order Exploratory Factor Analysis (EFA) was conducted to identify drivers for sub-scales (8 variables) of the questionnaire. The principal axis factoring was used with an oblique rotation, specifically Direct Oblimin. The Kaiser-Meyer-Olkin (KMO) measure supports the sufficiency of the sample for undertaking factor analysis, KMO = 0.95. Moreover, Bartlett's Test of Sphericity (χ^2=2766.028, p < 0.001) affirms that there are significant correlations among the variables and thus it is appropriate to use factor analysis. No extreme outliers were identified.

The eigenvalues of the initial two factors both exceed 1 with values being 1.16 and 8.32, indicating their substantial impact. The communality of each variable is above 0.6 (most are above 0.7) and thus the Kaiser's criterion (Eigenvalue > 1) was used and two factors were retained (Field, 2018). As additional factors are introduced, the eigenvalues experience less pronounced alterations. These two factors account for 75% (74.986%) of the total variance, with each factor explaining over 5% of the variance. Consequently, it could be concluded that two factors account for most of the variability.

The "technology anxiety" was excluded from further analysis as it exhibited low loadings (< 0.3) on both factors. Following its removal, each of the two factors encompassed more than three variables with statistically significant loadings, adhering to a predetermined minimum factor loading threshold of 0.40. This two-factor model demonstrated a precisely "simple structure", where all variables manifested comparatively high loadings on one factor and low loadings on the other factor (Schonrock-Adema et al., 2009).

Figure 6 shows that the variables are grouped distinctively around the ordinate and the abscissa, which defined the two key drivers for teacher satisfaction. The coordinate along each axis represents the Pearson correlation between a factor and a variable. The 2 variables along the ordinate have high correlations with factor 2 and low correlations with factor (1)

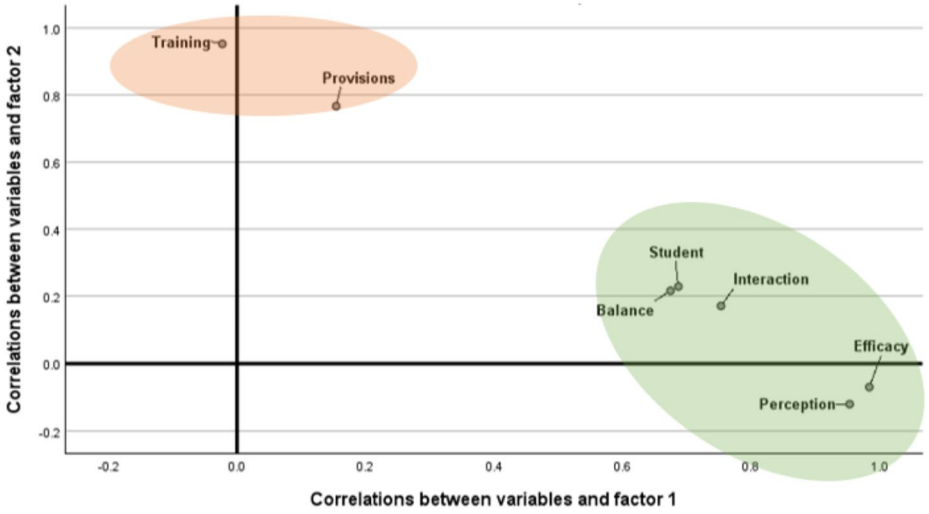

Fig. 6 Factor plot – intrinsic factor and extrinsic factor (Note: Correlations refer to Pearson correlation coefficients.)

The 5 variables along the abscissa have high correlations with factor 1 and low correlations with factor (2) A close look at the variables on each axis revealed that each group could be identified and related to certain human needs. On the abscissa, the group was identified as an internal factor or intrinsic factor, whereas on the ordinate, the group was linked with an external factor or extrinsic factor. This classification supports the application of the two-factor theory of job satisfaction in the context of online teaching (Herzberg, 2008).

Factor 1 refers to internal/intrinsic variables, i.e., online interaction, perception of online teaching, and online self-efficacy. Factor 2 refers to external/extrinsic variables, i.e., technology training, technology support, and incentives. Factor 1 and Factor 2 contain 75% of the total variance, i.e., 75% of teacher satisfaction is explained by Factor 1 and Factor 2 together. This results confirms that the Herzberg's two-factor theory of job satisfaction (Herzberg, 2008) can be applied to online teaching satisfaction. Here, the intrinsic factor appeared to be the most influential driver containing 67% of the total variance, and this is in line with the work of Basbeth et al. (2021).

Table 6 shows the factor loadings and communalities (h^2) of 7 variables. Factor loadings refer to how much of the variance in an observed variable is explained by the corresponding factor. Communality (h^2) refers to the proportion of an observed variable's variance that is explained by the common factors. Communality can be defined as the sum of squared multiple correlation of each variable with all other variables (see Eq. 1 below). In this research, communalities indicate how well the two factors (intrinsic and extrinsic factors) account for the variability in each of the 7 variables. The closer the communality is to 1, the better the variable is explained by the factors and the model.

$$h^2 = \sum_{i=1}^{m} \left(factor\ loading_{ij}\right)^2 \tag{1}$$

Where h^2 is the communality of the variable, m is the number of factors and $factor\ loading_{ij}$ is the loading of variable j on factor i.

All variables exhibit a communality exceeding the 0.7 threshold. Both self-efficacy (h^2=0.875) and training (h^2=0.875) have a high communality, which means these two variables are very well represented by the two factors. These findings indicate that the two-factor model effectively encapsulates the representation of all variables. The last row of Table 6 shows that the intrinsic and extrinsic factors of the scale demonstrate a high level of reliability, indicated by a coefficient value of 0.974, and 0.952. These results signify commendable internal consistency within the scales and further supports the appropriateness of the two-factor model. Table 7 shows the structure matrix (factor correlation matrix) in factor analysis, which reflects the relationships between observed variables and factors while considering the correlations among the factors themselves. Results are similar to pattern matrix (Table 6).

Figure 7 depicts the factor loadings and communalities of 7 variables within a 3D space along with the projection (orange ellipse) of factor loading values onto the base plane. This illustrates the clustering of the 7 variables, similar to the factor plot in Fig. 6. Here the extrinsic satisfaction is the interplay of two variables, while five are associated with intrinsic satisfaction. The perception and self-efficacy have the highest factor loadings on intrinsic satisfaction, whereas training has the highest factor loadings on extrinsic satisfaction.

In terms of communalities of each variable, the higher the values the greater are the communalities; in other words, higher values signify that a variable is well-represented by intrinsic and extrinsic factors together. All 7 variables exhibit communalities surpassing 0.70, indicative of the model's robust explanatory power. Specifically, variables such as self-efficacy (h^2=0.875) and training (h^2=0.875) demonstrate higher communalities. In contrast, variables like balance (h^2=0.712) exhibits comparatively lower communalities among the variables. However, all variables have communalities over the threshold of 0.7 and thus can be well represented by the two factors (Field, 2018).

A factor score refers to a composite score for each participant on a certain factor. The results of a Spearman correlation analysis show that the factor scores of Intrinsic aspect, Extrinsic aspect and overall satisfaction are correlated. It is expected to be so because internal and external satisfaction cannot be totally separated, and they influence each other. Internal satisfaction is significantly correlated with external satisfaction (r=0.798, p<0.01). Intrinsic satisfaction (r=0.890, p<0.01) and extrinsic satisfaction (r=0.706, p<0.01) are both significantly correlated with overall satisfaction. This result adds more evidence in favour of using oblique rotation, which allows for factors be correlated with each other. The findings suggest that extrinsic factors influence intrinsic factors; for instance, external support on digital technology directly impacts internal factors such as teacher self-efficacy.

Table 7 Factor correlation matrix (structure matrix) of 7 variables

		Factor	
No.	Variables	1	2
1	Student	**0.852**	0.722
2	Sel-efficacy	**0.934**	0.636
3	Perception	**0.867**	0.563
4	Interaction	**0.876**	0.712
5	Balance	**0.830**	0.700
6	Training	0.660	**0.935**
7	Provisions	0.704	**0.877**

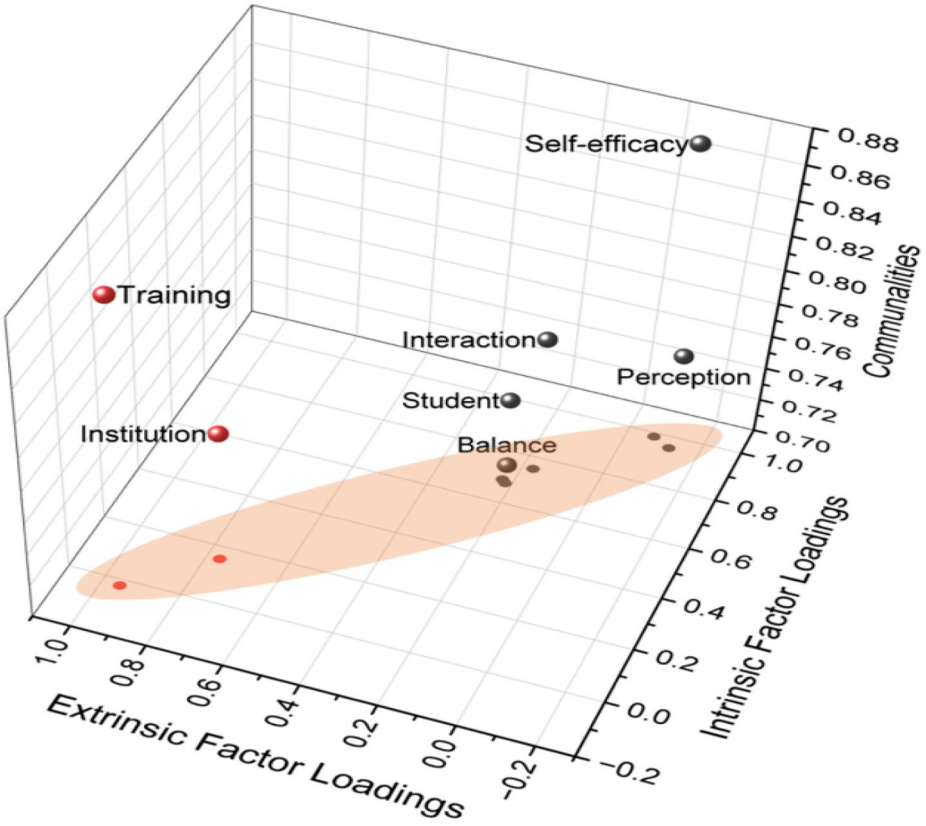

Fig. 7 3D scatter plot of 12 scales' factor loadings and communalities

Similarly, training in online delivery methods improves teachers' interactions with students. Therefore, extrinsic plays a significant impact in overall teacher satisfaction. Since it is difficult to influence internal factors, extrinsic factors seem even more important if the institution wants to raise teacher performance and satisfaction.

The scatter plot of factor scores of Internal Satisfaction versus External Satisfaction (Fig. 8) shows that all teachers on the space are spanned by the two factors. There is no natural grouping of teachers, and they form a continuum. There is an upper triangle shape, indicating that few participants are externally satisfied and internally dissatisfied (the larger blue triangle). No participants are externally dissatisfied and internally satisfied (the smaller blue triangle). This further illustrates that internal and external factors affect each other. Although internal and external satisfaction correlate with each other, some teachers are unsatisfied with institutions but internally happy to some extent.

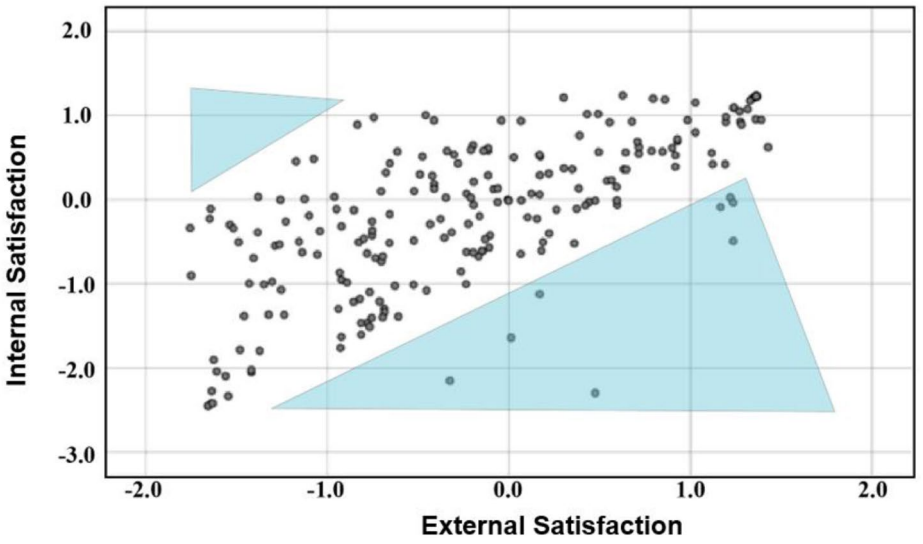

Fig. 8 Scatter plot of Internal Factor vs. External Factor

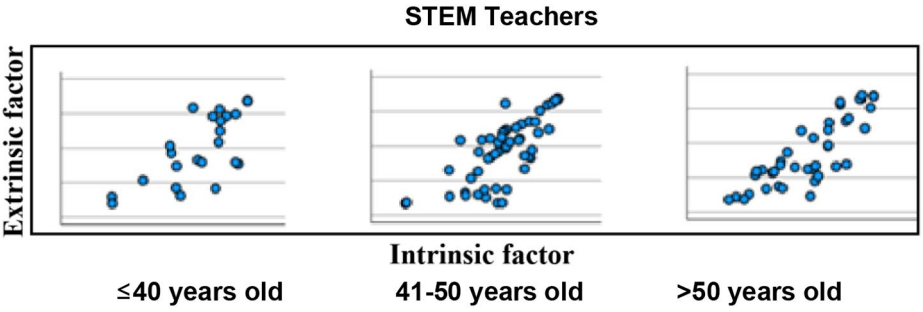

Fig. 9 Internal factor (x-axis) and external factor (y-axis) of STEM teachers by age group

3.3 Satisfaction Baseline - Research Question 3

3.3.1 Satisfaction by Age and Subject

Extending the scatter plot in Fig. 8, one could categorise the respondents by age group and subject to provide more contrast in these two underlying factors, as illustrated in Figs. 9 and 10. Here, a clearer positive correlation of intrinsic versus extrinsic factors is observed with an indication that, in this study, there were more STEM (Science-Technology-Engineering and Maths) respondents than non-STEM respondents.

The factor analysis in Sect. 3.2 above shows that the intrinsic factor has more impact on teacher satisfaction, and therefore, the internal aspect was explored further in terms of age and subjects. The results of a general linear model show no significance (Table 8). Therefore, the findings in this section (Fig. 11) cannot be generalised to all schools, and it only shows the pattern in the sample of the current research.

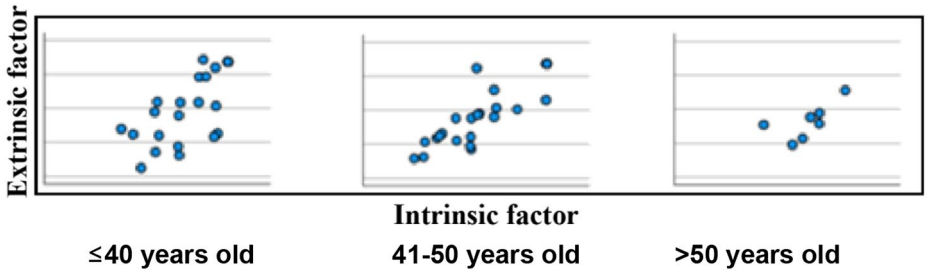

Fig. 10 Internal factor (x-axis) and external factor (y-axis) of non-STEM teachers by age group

Table 8 General linear model: tests of between-subjects effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.930[a]	5	1.386	1.465	0.202	0.029
Intercept	0.027	1	0.027	0.028	0.866	0.000
Subject	0.793	1	0.793	0.838	0.361	0.003
Age Group	2.213	2	1.106	1.169	0.312	0.010
Subject * Age Group	2.833	2	1.417	1.497	0.226	0.012
Error	228.048	241	0.946			
Total	234.978	247				
Corrected Total	234.978	246				

a. *R Squared = 0.029 (Adjusted R Squared = 0.009)

*Dependent Variable: regression factor scores of the internal factor

Figure 11(a) shows that among participants in STEM, teachers above 50 years have much lower inner satisfaction than other age groups. However, in non-STEM, the inner satisfaction of the age group (>50) is higher than that in STEM. This shows that STEM teachers' inner satisfaction decreases as age increases (see Fig. 11c). In general, STEM teachers have a lower internal satisfaction (M = 3.44, SD = 1.34) than non-STEM teachers (M = 3.60, SD = 1.20). External satisfaction follows a very similar pattern to internal satisfaction (Fig. 11b and d).

3.3.2 Technology Anxiety, Age, and Gender

To explore the reasons for a lower satisfaction among elder teachers in STEM, all variables were explored against the characteristics of participants, e.g., age and gender. Figure 12 depicts that the mean of technology anxiety is higher among elder and female teachers. Elder educators exhibit elevated levels of technological anxiety when using the new teaching platform. The reason is that younger age cohorts encounter and engage with emerging technologies to a greater extent compared to their older counterparts. Female teachers above 50 years old are the least comfortable with using the new teaching platforms. Male teachers no more than 40 years old are most comfortable, much better than their female counterparts. There are no gender differences in the cohort of teachers at the middle-aged cohort (41–50 years old).

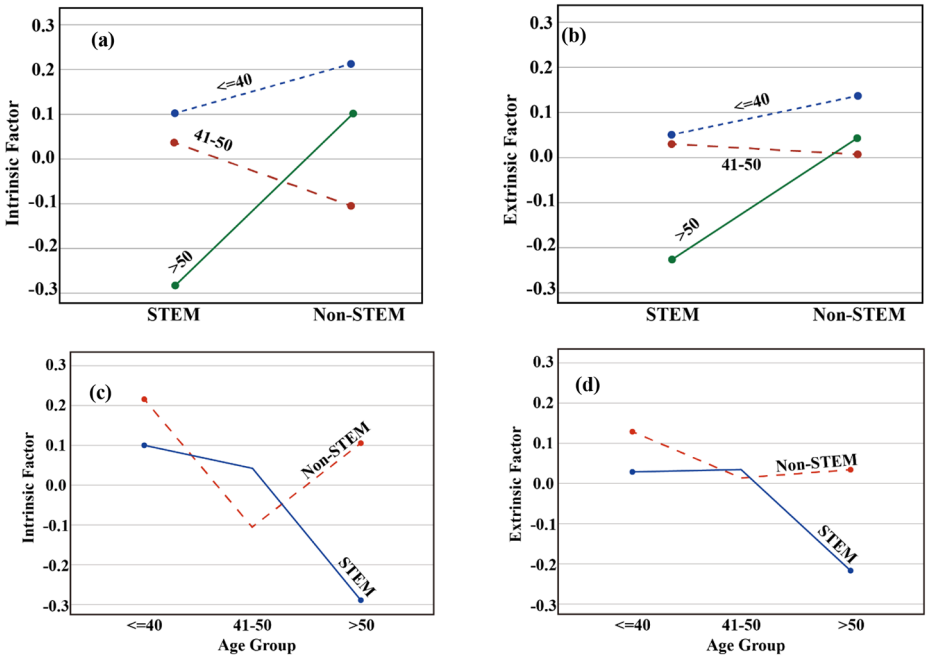

Fig. 11 Intrinsic and extrinsic satisfaction by subject and age group

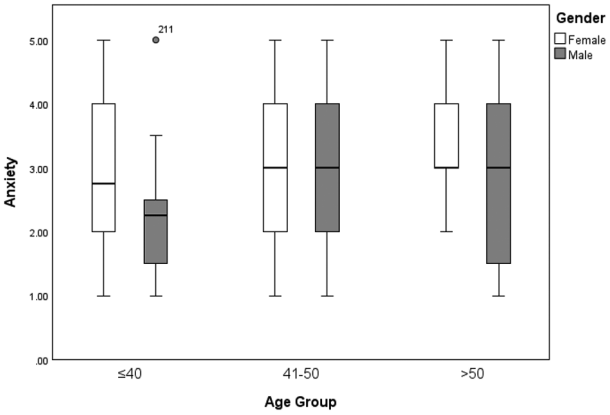

Fig. 12 Technology anxiety by gender and age group using boxplot analysis. Note Mean technology anxiety. 1 = Minimum Technology Anxiety, 5 = Maximum Technology Anxiety

4 Discussion

4.1 A Two-Factor Model and its Implications

Among the various indicators for teacher satisfaction explored in this research, the intrinsic and extrinsic factors are the key hidden drivers, with internal aspects having a stronger effect on overall satisfaction. These two factors and overall satisfaction are highly correlated with each other, which indicates that internal and external factors complement each other and that they together affect overall satisfaction. The practical implication is that policy

makers should pay attention to both factors and allocate resources accordingly to improve teacher satisfaction. If the institution wishes to increase teacher happiness and performance, external factors seem even more important because internal factors are difficult to change.

Figure 13 shows an overview of the two-factor model of online teaching satisfaction, with intrinsic and extrinsic forces being the key drivers for teacher satisfaction in online education. Since the extrinsic factor are forces acting on teachers, they can be termed as Institution-System to which teachers subdued hence have little or no effects. However, Institution-System is a powerful tool that if well designed and deployed could drastically improve performance in Staff-System. Institutional system includes various types of provisions, e.g., incentives, policies, technology support and training for online and conventional teaching. The intrinsic factor are elements of feelings, preferences, and perceptions that each teacher internalises, and thus it can be referred to as Staff-System. Institutional system directly affects Staff-System, which includes various aspects, namely, teachers' self-efficacy, teachers' satisfaction with students, their perceptions of online teaching, work-life balance, and interactions among teachers and students. Similar findings exist in other researches, where self-efficacy plays an important in teachers (Masry-Herzallah, 2023; Rauseo et al., 2022; Simon et al., 2024) and students satisfaction (Koca et al., 2023). The intrinsic factor contributes more to overall satisfaction statistically, yet it is easily affected by the Institution-System. Extrinsic significantly affects intrinsic ($\beta = 0.773$, $p < 0.01$) and therefore is a crucial element. Since the intrinsic aspect of teachers is difficult to change, policy makers should put emphasis on the extrinsic factor. Specific measures that can improve extrinsic satisfaction include appropriate training for online instruction and teaching platforms, policies based on teacher needs, and prompt technical support to support online teaching activities. Research underscores the significance of teacher training in enhancing technological competence, satisfaction, and performance (Joshi et al., 2022; Li & Yu, 2022; Marín-Marín et al., 2023; Saeed et al., 2021; Sáez-López et al., 2023).

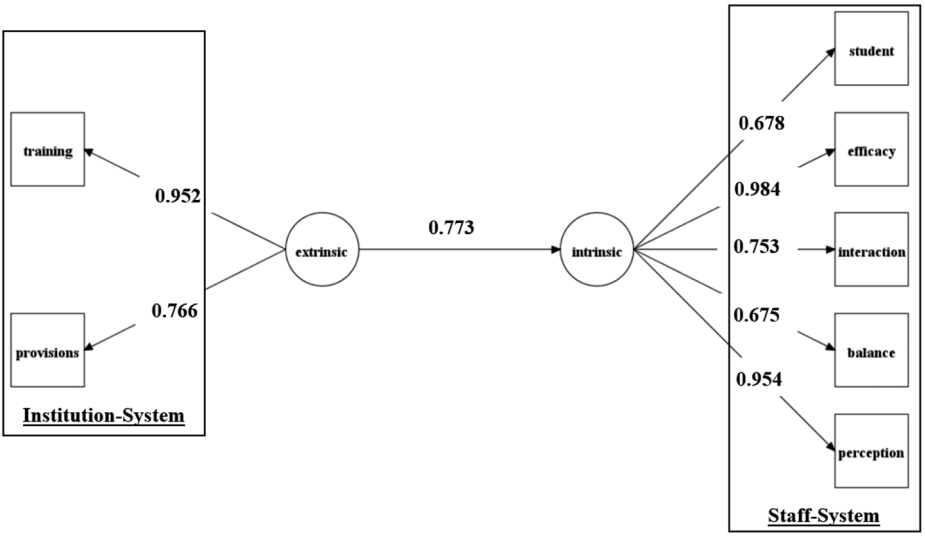

Fig. 13 A two-factor model of teacher satisfaction with online teaching

Increased intrinsic satisfaction can be derived from a flexible timetable, a feature often constrained in traditional lecture room settings due to fixed schedules and room occupancies. Difficulties arise in rescheduling lectures or seminars when the allotted room has a predetermined timetable, leading to wait times for both lecturers and students outside the classroom. Delays in one session can subsequently disrupt the entire timetable. The adoption of blended teaching alleviates these challenges by allowing for greater flexibility. Through mutual agreement between students and tutors, extra lecture times can be adjusted, providing a substantial advantage in workload management for tutors who can organize their schedules accordingly. Furthermore, online teaching significantly reduces commuting time, particularly in densely populated urban areas with frequent traffic congestion, enabling instructors to allocate more time to preparing for their teaching responsibilities. In summary, the flexibility offered by online or blended teaching facilitates an easier balance of life and work for both tutors and students.

Participants engaged in this research display satisfaction concerning flexibility and work-life balance online teaching provides. Policymakers are presented with a strong case by teachers' increased confidence and positive views regarding the effectiveness of online education. Support for flexible scheduling appears to be a powerful means of significantly increasing teacher satisfaction across a wider range of factors.

Conversely, instructors express notable dissatisfaction, particularly in terms of provisions, i.e., incentives, institutional policies, and technology support during online teaching. To address this unhappiness, an all-encompassing approach that includes focused incentives, prompt technology support and careful policy analysis is necessary. In order to create an atmosphere that supports efficient teaching methods, it is crucial to match these activities with the requirements and expectations of instructors.

4.2 Satisfaction as a Function of Age and Subject

In general, STEM teachers have lower satisfaction than non-STEM teachers in the cohort of participants in this research. The reason might be that it is very difficult for STEM teachers to run experiments, carry out hands-on activities and illustrate how things work during online teaching. Thus, students do not assimilate taught materials as they would do in a physical class. This discrepancy between input (teacher effort) and output (student experience) imposed by the virtuality of teaching frustrates student-centred teachers, as there is no means to manage an online class. This implies that STEM teachers need targeted resources, support, and pedagogies to tackle challenges in teaching online. This need for support was evidenced by a research carried among STEM teachers in 32 European countries, discovering that the Ease of Use is the most important indicator for teachers' intention to use mobile-based assessment, and facilitating conditions and output quality are the most important external element (Nikou & Economides, 2019). Facilitating STEM teachers to use the technology more easily and providing technical support are important.

STEM Teachers who have long years of teaching practice and experience with physical classrooms have a higher inner dissatisfaction with online teaching. This could also be explained by their lack of preparedness and aptitude to handle the sudden introduction of new technology for teaching. It is well known that younger generations are more exposed to emerging new technologies than older generations. The fear of breaking things or the possibility that something might not work can arise, especially when the technology often goes

wrong. When it doesn't work, what could be the solution? All these stressors are technology anxiety which contributes to hidden dissatisfaction. This finding echoes the discovery that the quality of personal digital technology affects student satisfaction, health, and wellbeing in online learning (Šorgo et al., 2023) and the current study provides new evidence from teachers' perspectives. While this holds true for all experienced teachers, STEM teachers, in particular, often lack a backup solution when faced with such situations. On the other hand, non-STEM teachers can pass on the lesson to students for self-study. There are similar findings from other studies that an older ages means lower satisfaction (Marín-Díaz et al., 2022). However, some other research prove that older teachers were more satisfied with online learning or other type of technology such as Augmented Reality, even same authors get different conclusions in different researches (Marín-Marín et al., 2023; Masry-Herzallah, 2023). That implies that the effect of age on teacher satisfaction depends on the context. And the current research highlights that subjects they teach influence how age affects the satisfaction.

In addition, STEM teachers with many years of teaching experience may be comparing student performance with that of past years and probably feel disappointed seeing the decline in students' achievement. This is true because engineering students during the COVID period did not have real laboratory practice, and hence, their experience in practical engineering and their success rates left much to desire. However, for non-STEM subjects, online teaching does not hinder the delivery of lessons. This may be due to the abstractness of some subjects where effective learning does not require much physical interaction, e.g., subjects requesting creativity, listening, reading, imagination, etc., from the students. Here, in the majority, the students are self-driven, and the learning occurs somehow more at the pace of the student, with moderate physical interaction with the teacher. For example, the teaching of art, painting, music, and philosophy would have almost similar effects in a physical classroom as in a virtual online classroom. In one of their publications, the author observed that online delivery facilitated interaction and that students and teachers enjoyed doing creative work (Yan & Batako, 2020).

4.3 Limitations and Suggestions for Future Research

Despite the innovative validation of the model using evidence from 10 countries worldwide, still there are some limitations this research. The sample size and geographic variation of participants are not comprehensive due to constraints in time and resources, as well as limitations in direct access to participants during the administration of the questionnaires. In certain countries, a lack of access to technology impeded some aspects of the fullness of this work. Future research should aim to provide more extensive evidence across diverse contexts. Additionally, longitudinal analysis is necessary to track changes over time and understand long-term trends. As this research is predominantly quantitative, incorporating qualitative approaches utilising interviews or focus groups could enrich the understanding of teacher satisfaction and provide a more comprehensive perspective. Future research is currently in progress using a mixed-methods design, combining both quantitative and qualitative approaches, to gain deeper insights into teacher satisfaction.

5 Conclusions

This work investigated how teachers perceived themselves in online teaching in terms of satisfaction. A questionnaire was developed and widely distributed across the globe, reaching approximately 250 teachers in 10 countries, including China, Malaysia, United Arab Emirates, Togo, Ethiopia, France, the UK, Poland, Russia, and Ukraine. The collected data were studied in SPSS and Mplus, revealing two hidden key drivers that affect the satisfaction with online teaching. An innovative two-factor model (Staff-System and Institution-System) for teacher satisfaction was developed. The application of the findings can be extended to teacher satisfaction in physical classrooms.

First, the participants in this study exhibit a good satisfaction with flexibility and work-life balance and have a lower satisfaction with provisions such as incentives, institutional policies, and technical support. Their elevated self-efficacy and positive perceptions of the utility of online teaching suggest to policymakers that, the implementation of flexible scheduling would significantly enhance overall teacher satisfaction. Conversely, the respondents expressed the least satisfaction with incentives and institutional policies during online teaching. To address this discontent, strategic incentives and a reassessment of policies are needed, ensuring alignment with teachers' requisites and expectations to promote effective teaching practices.

Moreover, from this study, it emerged that teachers are driven by extrinsic and intrinsic factors with reference to their satisfaction in the context of online teaching. There are factors that teachers internalise (intrinsic), i.e., work/life balance, perception, interaction with students and colleagues, self-efficacy, etc., and there are factors that are external to the teachers (extrinsic), e.g., incentives, provision of training, institutional policies affecting teachers, available technical support, etc.

- The intrinsic factor (Staff-System) contributed more to overall satisfaction. However, it was observed that the intrinsic and extrinsic factors are inseparable and positively correlated with each other (see Fig. 8), explaining 75% of teacher satisfaction. Therefore, education management should further explore these two key drivers by collaborating with teachers to understand and address their intrinsic needs, thereby improving the online teaching experience.
- Extrinsic factor (Institution-System) is more important since it provides the tools necessary to achieve desirable performance in the Staff-System. It is easier to change than the Staff-System and thus needs more attention from policy makers. Policy reviews, technological support, and targeted incentives designed to meet the needs of the Staff-System could significantly enhance staff and student experiences. It's critical to align these activities with institutional expectations from teachers to foster an environment that ensures effective teaching. The provisions such as technical training and support will also enhance teachers' self-confidence in teaching, which is beneficial for teacher satisfaction and learner experience.

In addition, the lower satisfaction displayed by STEM teachers calls upon the educational systems to revise how STEM lessons are delivered online. There is a need to investigate into the challenges in conveying the fundamentals and practical aspects of STEM subjects virtually. More effective virtual tools and pedagogies need to be developed for experiments and hands-on activi-

ties to improve learning experience of STEM students. Additional support and resources could be provided for STEM teachers considering the unique challenges they encountered. There may be adequate technologies facilitating online teaching, yet institutions may need to ascertain the perception of these technologies by older teachers and their attitude and aptitude in using these new technologies. This would help provide timely and adequate targeted training and support to older teachers who had less early exposure to new technologies, which could reduce technology anxiety and enhance their satisfaction / performance.

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Author Contributions All authors made substantial contributions to the conception and design of the study. Ning Yan, Aiping Zhang, and Andre Batako were responsible for material preparation and data collection. The data analysis was conducted by Ning Yan, Andre Batako and Gabriela Czanner. The initial draft of the manuscript was composed by Ning Yan, and all authors provided valuable feedback and comments on earlier versions of the manuscript. Finally, all authors carefully reviewed and approved the final version of the manuscript for submission.

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Data Availability The datasets generated and analysed during the current study are not publicly available due the fact that they constitute an excerpt of research in progress but are available from the corresponding author on reasonable request at n.yan@2021.ljmu.ac.uk.

Declarations

Ethical Approval All procedures were conducted in strict accordance with the ethical guidelines set forth by the institutional research committee, as well as in compliance with the 1964 Helsinki Declaration and its subsequent amendments or similar ethical standards. Ethics approval was obtained from the host institution.

Consent for Publication All individuals involved in our research are fully aware of the publication process and provide their informed consent for the inclusion of their contributions in the paper.

Informed Consent Every individual participant included in the study provided informed consent before their involvement in the research. Participants are fully informed about the research objectives, procedures, potential risks, benefits, and their rights before they agree to participate voluntarily.

Human Participants and Anonymity The work was entirely anonymous and contains no personal identifiable information. The study was designed in a manner that minimizes any potential risks and discomfort to participants while maximizing the benefits of the research.

Competing Interests There are no relevant financial or non-financial interests that could influence the impartiality and objectivity of the research findings presented in this study.

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