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Multi-dimensional alignment between online instruction and course technology: A learner-centered perspective

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ABSTRACT

Compared with face-to-face instruction, online instruction in distance and hybrid education relies on the extensive use of course technology. Course technology supports multiple aspects of online instruction including objective specification, material organization, engagement facilitation, and outcome assessment. This study looks into different dimensions underlying the alignment between online instruction and course technology, and investigates the direct and indirect effects of involved constructs on student satisfaction as the outcome variable. The empirical evidence from a survey supports most research hypotheses, and suggests that instruction-technology fit is a partial mediator for online instruction and a full mediator for course technology in terms of their relationships with student satisfaction. Whereas all alignment dimensions but assessment fit are significant, engagement fit calls for closer attention than objective fit and material fit. That is, course technology has great potentials as well as a big space for improvement to facilitate the student engagement aspect of online instruction. From a learner-centered perspective, the findings offer researchers and practitioners helpful insights on how to utilize all kinds of e-learning tools for student success.

1. Introduction

Advances in electronic learning transform higher education by giving students more flexibility and control while maintaining high standards of instructional quality (Garrison, 2011). In 2012, around one third of American college students took one or more online courses and such distance learning enrollment had been increasing at a much faster pace than overall higher education enrollment during the past 10 years (Allen & Seaman, 2013). In terms of development stages, online education has surpassed the first two levels of "personal productivity aids" (e.g. automatic office tools) and "enrichment add-ins" (e.g. multi-media content, computer-mediated communication), and is in the final process of "paradigm shift" that requires the redesign and reconfiguration of course content and delivery to facilitate active learning for students (Rogers, 2000; Schneckenberg, Ehlers, & Adelsberger, 2011).

Compared with face-to-face teaching that can be divided into individual classes, online instruction needs to take a more holistic approach in the design and delivery of course modules, each comprising multiple learning components (Barajas & Owen, 2000; Van Merriënboer & Kirschner, 2013). In distance and hybrid education, online instruction components need to be clearly defined and implemented with the support of appropriate e-learning tools (Martyn, 2003; Sun & Wang, 2014). In a virtual environment, for instance, a group project is conducive to collaborative learning only if teamwork activities are well

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facilitated by groupware tools like discussion board and web conferencing. In this sense, online course development can be viewed as the process of integrating instructional content and course technology to enhance distance learning experiences for students (Fink, 2013; Henry, 2001).

One critical success factor of distance learning, therefore, is the alignment between online instruction and course technology (Angeli & Valanides, 2005; Bennett, Bishop, Dalgarno, Waycott, & Kennedy, 2012; Chen, Wu, & Yang, 2006; Singh, Mangalaraj, & Taneja, 2010). Due to the complex nature of online instruction, its relationship with course technology is unlikely to be simple. However, most researchers regard their alignment unidimensional in conceptualization and operationalization. Perceived fit, or the overall perception of how course technology fits the need of online instruction, is typically used (e.g. Gu, Zhu, & Guo, 2013; McGill & Klobas, 2009). The unidimensional approach simplifies analyses but also limits the insights of findings. For instance, some aspects of alignment may be more critical to the success of online courses than others. Treating them as the same makes it hard to prioritize efforts.

This study examines the multi-dimensional alignment between online instruction and course technology, and develops a research model to investigate its relationships with other variables. Then the article describes measurement development and data collection to test the hypothesized relationships. Finally, it presents the results of statistical analyses and discusses the implications of findings, followed by the conclusion.

2. Research background

The concept of alignment originated in management literature, such as the fit between business strategy and organizational structure (Kathuria, Joshi, & Porth, 2007). There are six general approaches to conceptualize fit as: 1) moderation, 2) mediation, 3) matching, 4) covariation, 5) profile deviation, and 6) gestalt (i.e., an organized whole) (Venkatraman, 1989). In the field of information systems, researchers mainly examine the alignment between technology use with either strategies at the organizational level or tasks at the individual level (Chan & Reich, 2007).

The critical alignment issue in online course design and delivery concerns the use of specific e-learning tools to support various online instruction activities. For such task-related alignment, the most well-known theory is the task-technology fit (TTF) model. Based on the fit-as-matching conceptualization, the model suggests that both task performance and technology utilization are enhanced if technology characteristics match task characteristics (Goodhue & Thompson, 1995).

The original TTF scale includes 16 factors including the right data, the right level of detail, accuracy, compatibility, locatability, accessibility, flexibility, meaning, assistance, ease-of-use of hardware and software, systems reliability, currency, training, authorization, presentation and confusion (Goodhue, 1998). Factors like ease-of-use of hardware and software and compatibility overlap with constructs in other theories, such as ease-of-use in Technology Acceptance Model (Davis, 1989) and compatibility in Innovation Diffusion Theory (Rogers, 2010). Among the other TTF factors, accuracy, accessibility and reliability are more pertinent to general information quality than specific tasks (Lee, Strong, Kahn, & Wang, 2002).

Most studies that adopted the concept of task-technology fit only used a few questionnaire items to directly measure the perceived fit between task and technology. In the context of online education, such items often use descriptions like: “course technology fits well with the way I like to study” and “course technology is compatible with all aspects of my study” (Gu et al., 2013; McGill & Hobbs, 2008). They are used as the reflective indicators of the latent variable of perceived task-technology fit in the modeling of its relationships with other variables.

Reflective modeling follows the basic premise of psychometrics: a human subject’s response to a scale reflects the individual’s underlying “true score” of psychological state (DeVellis, 2012). When task-technology fit is conceptualized as a reflective construct, therefore, it is supposed to be unidimensional in nature. That is, the perceptional indicators of such a reflective construct are “caused” by the same source of psychological influence, and should exhibit a relatively high level of internal consistency (Spector, 1992).

Yet the alignment between online instruction and course technology, or instruction-technology fit, may involve more than a single dimension. Online instruction is an endeavor comprising multiple aspects of efforts, and course technology needs to support all of them to make a course successful. Nevertheless, it is possible that course technology is better aligned with some aspects of online instruction than it is with other aspects.

A formative construct comprises various dimensions that contribute to its formation in various ways and are not necessarily consistent with each other (Petter, Straub, & Rai, 2007). Instead of using the unidimensional perceived fit construct, this study conceptualizes instruction-technology fit as a formative construct following the fit-as-gestalt approach to capture different aspects of the alignment between online instruction and course technology. The indicators of a formative construct are heterogeneous in nature as they constitute its different dimensions, in contrast to the homogenous indicators of a reflective construct (Bollen & Lennox, 1991). Thus, the measurement validity of a formative construct should be examined based on the theoretical relevance and conceptual completeness of its indicators rather than their internal consistency (Hair, Black, Babin, & Anderson, 2009).

One of the most authoritative and comprehensive guidelines to evaluate the design of online courses is the Quality Matters Higher Education Rubric (simply, QM Rubric) (Shattuck, 2010). The examination of its structure may provide useful clues for identifying the dimensions of instruction-technology fit and related constructs. The latest edition of QM Rubric comprises eight general standards as listed in Table 1 (Quality Matters, 2014). For each standard, there are specific rubric items to evaluate the relevant aspect of online course design. There are 21 three-point items, 15 two-point items, and 8 one-point

Table 1
QM rubric summary.

No.	Standard	Category	Number of items			Points
			3-pt	2-pt	1-pt	
1	Course overview and introduction	–	2	3	4	16
2	Learning objectives	Instruction	5	0	0	15
3	Assessment and measurement	Instruction	3	2	0	13
4	Instructional materials	Instruction	2	3	1	13
5	Course activities and learner interaction	Instruction	3	2	0	13
6	Course technology	Technology	2	1	2	10
7	Learner support	Technology	2	1	1	9
8	Accessibility and usability	Technology	2	3	0	12
		Total	**21**	**15**	**8**	**101**

items, leading to 44 items and 101 points in total. Out of all, the 21 three-point items are deemed essential as they count for more than 60% of total points.

Out of the eight standards, five pertain to critical course components that must work together to ensure the quality of online learning for students, and they are: learning objectives (Standard 2), assessment and measurement (Standard 3), instructional materials (Standard 4), course activities and learner interaction (Standard 5) and course technology (Standard 6) (Quality Matters, 2013). A close look at specific rubric items reveals that Standard 6 on course technology is primarily about its alignment with the other critical course components.

Among the remaining three standards, Standard 1 aims to inform students of overall course layout, and Standard 7 on Learner Support and Standard 8 on Accessibility and Usability are closely related to students' effective utilization of course technology. Except for Standard 1, therefore, the standards in QM Rubric can be divided into two general categories: four instruction-related standards (Standards 2 through 5) and three technology-related standards (Standards 6 through 8). These seven standards contain 19 essential rubric items (out of 21 in total, each of which has three points), 13 from instruction-related standards and 6 from technology-related standards.

Existing theoretical and practical frameworks provide helpful insights on the conceptualization and operationalization of the alignment between online instruction and course technology. The next section develops a conceptual model on how such an alignment may form as well as a research model of hypothesized relationships among relevant variables.

3. Model development

Based on the literature review, Fig. 1 conceptualizes how online instruction and course technology may align with each other. As indicated by counter-clockwise arrows, the instruction-related QM standards concern the major efforts of online course design and delivery in an iterative development cycle. The efforts corresponding to learning objectives, instructional materials, course activities and learner interaction, and assessment and measurement, respectively, comprise online instruction as a whole. For empirical research, therefore, online instruction can be viewed as a higher-order formative construct of four dimensions - objective specification, material organization, engagement facilitation, and outcome assessment - each measured with multiple items.

Among the technology-related standards, Standard 6 on course technology pertains to its alignment with online instruction, and Standards 7 and 8 concern the functioning of course technology itself. Course technology needs to support all the efforts of online instruction in order to make the endeavor successful as a whole. Such an instruction-technology alignment forms through a two-way interaction: at the stage of course design, an aspect of online instruction imposes certain requirements on the choice of appropriate technology; at the stage of course delivery, the use of proper technology provides needed capability to support that effort. Therefore, instruction-technology fit comprises multiple dimensions corresponding to those of online instruction: objective fit, material fit, engagement fit and assessment fit. In course design and delivery, it is possible that an instructor aligns course technology well with some aspects of online instruction, but not the others. Thus technology-task fit is a formative construct that describes how well course technology is aligned to different aspects of online instruction altogether.

To support online learning, course technology itself needs to be functional to students. QM Standard 7 on Learner Support is related to the availability of technical support when students encounter any issues with course technology, and Standard 8 on Accessibility and Usability concerns how easy students can access and use the technology. Researchers confirm the importance of accessibility, usability and support to the effective use of course technology by students, which correspond to system quality, information quality and service quality respectively (De Freitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulovassilis, 2010; Delone & McLean, 2003; Fresen, 2007). Also as a formative construct, therefore, course technology captures the quality associated with the provision of e-learning tools to students in online courses from multiple aspects: 1) support, 2) accessibility, and 3) usability.

The conceptual model describes how the alignment between online instruction and course technology may form. However, the bottom-line question is what differences such an alignment makes in online education. To answer this question,

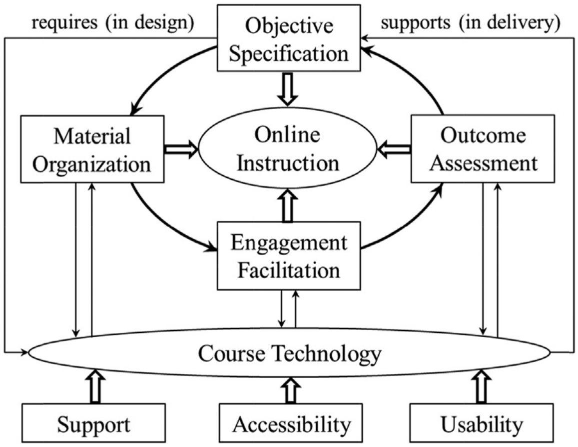


Fig. 1. Alignment between online instruction and course technology.

a research model needs to be developed and tested with empirical observations. The key components of a research model are explanatory (or independent) and outcome (or dependent) variables, as well as the hypothesized relationships among them. Based on the existing task-technology fit (TTF) model (Goodhue & Thompson, 1995), the rest of this section will discuss each of these components in the context of this study.

In the TTF model, the alignment between task and technology is the only explanatory variable that directly explains the dependent variables of task performance and technology utilization. In an online course, students' learning experiences are enhanced when course technology is aligned with online instruction. However, instruction-technology fit does not take effect by itself but rather synergizes the influence of online instruction and course technology on student learning. Based on the general premise of alignment, therefore, it is necessary to extend the TTF model to distance learning research by including online instruction and course technology as explanatory variables in addition to instruction-technology fit.

In terms of outcome variables, the TTF model explains both task performance and technology utilization as it studies how likely an individual is to adopt a technology for a task (Goodhue & Thompson, 1995). For online courses, there are two types of users: instructor users and student users. Instructors employ course technology to carry out online instruction, and students use course technology to facilitate their online learning. When a learning management system (LMS) like Blackboard is integrated into online curricula, it is instructors who decide which e-learning tools on the platform to utilize for online instruction but students who are given the tools to use in learning, leading to teacher-led locus of control (Liu & Chen, 2007). In this sense, technology utilization is a dependent variable more pertinent to instructors' choice of e-learning tools than students' actual use.

The other dependent variable of TTF model deals with task performance, which is related to how well students do in online courses. The quality of learner-centered online courses needs to be evaluated from the perspective of students (McCombs & Vakili, 2005). As well-designed online courses enhance learning experiences, student satisfaction is often used to evaluate course effectiveness (Young & Norgard, 2006). In most studies, student satisfaction is operationalized as a unidimensional reflective construct. In this study, however, it may not be sufficient to capture the influences of explanatory variables that are multi-dimensional in nature.

Like online instruction, student satisfaction may comprise multiple dimensions corresponding to different aspects of learning experiences. Among the dimensions of online instruction, objective specification and material organization pertain to the scope and content of learning, engagement facilitation concerns student participation, and outcome assessment addresses learning outcome. Therefore, there are three aspects of student satisfaction: learning satisfaction, participation satisfaction and outcome satisfaction. Accordingly, researchers found that students' satisfaction with online courses pertains to knowledge transfer, engagement level and learning outcome (Palmer & Holt, 2009). Capturing different aspects of learning experiences in online courses, Student Satisfaction is a formative construct as well.

With all the explanatory and outcome variables specified, the next step of developing the research model is to hypothesize the relationships among them. In the model, student satisfaction captures the influences of online instruction, course technology and instruction-technology fit. The findings of previous studies suggest that better course implementations in terms of online instruction and course technology lead to higher degree of student satisfaction (Swan, Day, Bogle, & Matthews, 2014). Capturing the synergy between two, instruction-technology fit is also likely to have a positive effect on the outcome variable. As shown in Fig. 2 and listed in Table 2, their relationships with student satisfaction are hypothesized as H1 for online instruction, H2 for course technology and H3 for instruction-technology fit.

Between two explanatory variables, it is possible that one affects the other, leading to the indirect relationship between one explanatory variable and the outcome variable through the mediation of another. Such a relationship typically implies that the mediator facilitates the influence of the other explanatory variable on the outcome variable (Hair et al., 2009). In this

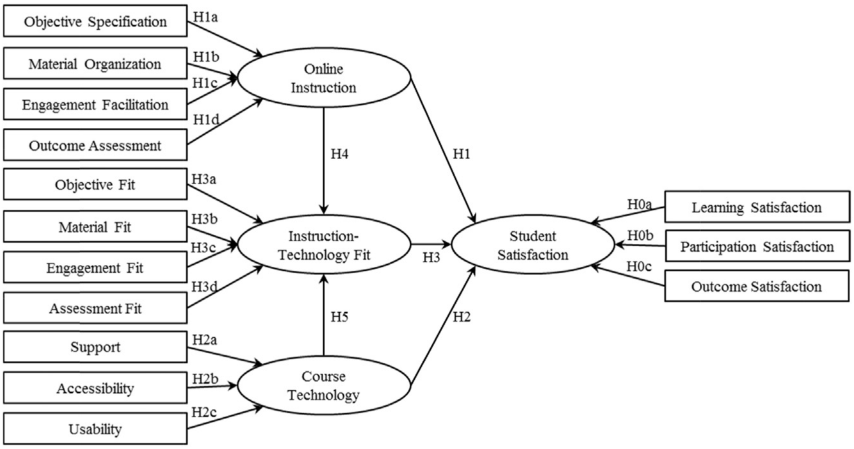


Fig. 2. Research model.

study, the alignment between online instruction and course technology is supposed to optimize the effects of both on student learning. In addition to their direct effects, therefore, online instruction and course technology have indirect effects on student satisfaction through the mediation of instruction-technology fit, as hypothesized with H4 and H5 respectively. This is consistent with the fit-as-mediation approach of conceptualizing alignment in terms of its relationship with other constructs.

For reflective constructs, factor loadings are part of measurement models and usually not included in research hypotheses to test structural relationships. For formative constructs, however, their causal indicators have conceptual unity and it is necessary to examine the structural effect of each (Bollen & Bauldry, 2011). In the research model, all the constructs are formative and their relationships with the indicators are hypothesized as well.

For online instruction, course technology, instruction-technology fit and student satisfaction, in specific, their causal indicators comprise the components of each. Thus such structural relationships within each construct are hypothesized as positive, as stated in Table 2. Actual estimates indicate the relative importance of causal indicators, leading to insights on which aspects of the constructs in question demand closer attention in online course design.

4. Methodology

To test the hypothesized relationships among constructs, data need to be collected from an empirical study. This section describes construct operationalization, survey procedure and study participants.

4.1. Measurement

A valid scale needs to make sure that the content domain of the construct in question is well represented with measurement items (Clark & Watson, 1995). For learner-centered online courses, what matters eventually is how students perceive and receive course delivery (Chou, 2001; Clark & Mayer, 2011). The collection of learner feedback allows instructors to optimize instruction-technology alignment in course development and enhancement. Mainly based on the QM Rubric, this study develops the Likert items in Table 3 to measure online instruction, course technology, instruction-technology fit and student satisfaction.

As for online instruction, a close look at original rubric items concerning objective specification, material organization, engagement facilitation, and outcome assessment suggests that they evaluate each effort from three main aspects: preparation, delivery and effectiveness. For the preparation aspect, the rubric uses phrases such as "objectives … are suited to the level of the course", "materials are current", "learning activities provide opportunities for interaction", "assessment instruments … are suited to the learner work". The delivery of prepared content to students is equally important, as suggested by terms like "objectives are … written from learner perspective", "materials … are clearly explained", "requirements for learner interaction are clearly stated" and "grading policy is stated clearly". Eventually, it is the effectiveness of student learning that matters, as indicated by phrases such as "learning objectives … are measurable", "instructional materials contribute to the achievement", "learning activities … support active learning", and "assessments measure … competencies".

Therefore, there are three measures to capture each dimension of online instruction related to its preparation, delivery and effectiveness. Take objective specification for instance, the first item concerns appropriateness, the second item pertains to guidance and the third item deals with measurability. Regarding engagement facilitation, its three items address participation means, interaction guidelines and active learning respectively. Similarly for material organization and outcome assessment, their items assess the development, explanation and application of learning materials and assessment instruments.

Table 2
Research hypotheses.

Label	Hypothesis
H0a	Learning satisfaction positively contributes to student satisfaction.
H0b	Participation satisfaction positively contributes to student satisfaction.
H0c	Outcome satisfaction positively contributes to student satisfaction.
H1	**Online instruction positively affects student satisfaction.**
H1a	Objective specification positively contributes to online instruction.
H1b	Material organization positively contributes to online instruction.
H1c	Engagement facilitation positively contributes to online instruction.
H1d	Outcome assessment positively contributes to online instruction.
H2	**Course technology positively affects student satisfaction.**
H2a	Support positively contributes to course technology.
H2b	Accessibility positively contributes to course technology.
H2c	Usability positively contributes to course technology.
H3	**Instruction-technology fit positively affects student satisfaction.**
H3a	Objective fit positively contributes to instruction-technology fit.
H3b	Material fit positively contributes to instruction-technology fit.
H3c	Engagement fit positively contributes to instruction-technology fit.
H3d	Assessment fit positively contributes to instruction-technology fit.
H4	**Instruction-technology fit mediates online instruction's effect on student satisfaction.**
H5	**Instruction-technology fit mediates course technology's effect on student satisfaction.**

Note: The relationships between student satisfaction and its components are labeled H0a-H0c, as learning satisfaction, participation satisfaction and outcome satisfaction comprise the outcome variable of student satisfaction, rather than explaining it as the other constructs do.

Compared with QM Rubric items that request relatively objective evaluation from course reviewers, the psychometric measures elicit more subjective responses from students based on their overall experiences from online learning. Thus the wording of each measure is somewhat more general than that of individual rubric items in question. For example, the preparation aspect of instructional material is captured with "instructional materials are carefully prepared", which students can tell. Rather, relevant rubric items like "the instructional materials are current" and "a variety of instructional materials is used in the course" may require some expert knowledge.

The measures of each dimension capture how a student perceives that particular aspect of online instruction based on the positive or negative experience with it. Under the same source of influence, the indicators of each dimension covary with each other, suggesting that they are reflective in nature (DeVellis, 2012). Therefore, objective specification, material organization, engagement facilitation and outcome assessment are reflective constructs by themselves as well as the formative indicators of online instruction, leading to the "reflective first-order and formative second-order" configuration (Diamantopoulos, Riefler, & Roth, 2008). For such a higher-order construct, item parceling is often recommended for reducing number of variables and enhancing estimation accuracy (Hall, Snell, & Foust, 1999). The average of item scores can be used as the index score for each dimension, reducing online instruction to a single-level formative construct.

Compared with online instruction, course technology and instruction-technology fit are simpler to operationalize. This is reflected by relevant standards and items in QM Rubric, as online instruction alone is assessed with four standards (Standards 2–5) of 20 items, but course technology and instruction-technology fit concern three standards (Standards 6–8) of 14 items altogether. Both technology-related constructs can be operationalized as first-order formative constructs. For each, formative indicators are supposed to capture different aspects of its content domain, and not necessarily covary with each other (Treiblmaier, Bentler, & Mair, 2011).

As instruction-technology fit concerns how course technology supports various aspects of online instruction, its operationalization must cover the alignment of technology with objective specification, material organization, engagement facilitation and outcome assessment. Based on the relevant items of QM Standard 6 on course technology (e.g. "support learning objectives" and "promote learner engagement"), one measure is developed for each of objective fit, material fit, engagement fit and assessment fit. Together, they comprise a student's overall perception of the alignment between online instruction and course technology.

On the other hand, course technology comprises three aspects: support, accessibility, and usability. Based on relevant QM Rubric items that contain key words like "technical support", "accessibility", and "ease of use", a measure is developed for each aspect. Finally, student satisfaction comprises three aspects related to learning, participation, and outcome. For each, one item is developed as well.

4.2. Procedure

To test the research model, survey data were collected from students taking online courses over the one-year period of time between 2014 and 2015. Constructs were measured with 5-level Likert items (1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree). The questionnaire was posted online and the link was distributed to student participants taking online courses. To enhance the response rate, the instructors of these courses sent out several rounds of

Table 3
Operationalization of constructs.

Construct	Dimension	Likert item
Online instruction	Objective specification	Learning objectives are appropriately set
		Learning objectives provide helpful guidance
		Learning objectives are defined in a measurable manner
	Material organization	Instructional materials are carefully prepared
		The explanations of instructional materials are clear
		Instructional materials enhance learning
	Engagement facilitation	Effective means are devised to promote student participation
		There are specific guidelines on learner interaction
		Students are engaged in active learning
	Outcome assessment	Proper instruments are used to assess learning
		Grading criteria are easy to understand
		Important learner competencies are evaluated
Instruction-technology fit	Objective fit	Course technology helps me reach prescribed learning objectives
	Material fit	Course technology facilitates my understanding of instructional materials
	Engagement fit	Course technology allows me to participate in learning activities
	Assessment fit	Course technology lets me demonstrate acquired competencies
Course technology	Support	Technical support is available when needed.
	Accessibility	Course tools are readily accessible.
	Usability	Course tools are user-friendly in general.
Student satisfaction	Learning satisfaction	I learned a lot from this online course.
	Participation satisfaction	I enjoyed the participation in this course.
	Outcome satisfaction	I am happy with the course outcome.

reminder messages and gave participants extra credits. The survey was anonymous, and at the end, participants captured the screenshot of “thank you” page and submitted it as a bonus assignment.

4.3. Subjects

Altogether 232 students were elicited, and 221 responses were collected. Among the responses, two were incomplete and the final sample size was 219. The valid response rate was 94%, which does not suggest a significant non-response bias. Among the participants in the sample, 106 were undergraduate students and 113 were graduate students. Most of the undergraduate participants were local students in business and social science programs at a university in the southern USA. The graduate participants, however, were from all over the nation as they were enrolled in the online master of business administration (MBA) and master of public administration (MPA) programs. The mixture of participants at both undergraduate and graduate levels and from different regions gave a relatively comprehensive representation of student population taking online courses. There were 122 females (56%) and 97 males (44%), and the average age was 29. On average, each participant had taken about five online courses, including the one currently enrolled.

5. Results

Table 4 gives the results of descriptive, reliability and collinearity analyses. First, the mean and standard deviation of different variables describe their response patterns. Participants had more positive responses to online instruction items than course technology items, whereas their average responses to instruction-technology fit items fell somewhere in between. Still perceived as a weak link in online course design, course technology deserves more effort to be truly aligned with online instruction.

Interestingly, engagement fit had the highest average score among instruction-technology fit dimensions, yet engagement facilitation and participation satisfaction scored almost the lowest among the indicators of online instruction and student satisfaction, respectively. The seemingly contradictory results point to both opportunity and challenge of online courses regarding learner engagement. On one hand, course technology can greatly facilitate active learning in a virtual environment; on the other, there is still a big space for improvement in this regard for distance and hybrid education.

For online instruction, each of its four dimensions was measured with multiple items, and the reliability of their responses was assessed. As the most commonly used reliability coefficient, Cronbach’s alpha assesses the internal consistency of item responses base on the domain-sampling theory that the reflective indicators of a latent construct share a homogeneous content domain (Cronbach, 1990). All the coefficient alphas of online instruction’s dimensions were well above the threshold of 0.7, indicating that the responses were internally consistent. This supports the calculation of index score for each dimension based on the average of item scores following the aforementioned practice of item parceling.

Based on such index scores, the internal consistency among four online instruction dimensions was further assessed and the coefficient alpha was pretty high. To assess possible common method bias due to the common-rater effects in survey studies, multi-factor models can be verified against corresponding single-factor models through confirmatory factor analyses (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). For all the indicators of online instruction dimensions, the default four-factor

Table 4
Descriptive, reliability and collinearity analyses.

Construct/Dimension	# of items	Mean (St. Dev.)	Alpha	VIF
Online instruction	4	–	0.90	1.97/3.54
Objective specification	3	4.47 (0.72)	0.88	3.13
Material organization	3	4.31 (0.86)	0.92	3.79
Engagement facilitation	3	4.32 (0.93)	0.89	2.05
Outcome assessment	3	4.48 (0.70)	0.86	3.69
Instruction-technology fit	4	–	0.94	4.59
Objective fit	1	4.34 (0.92)	–	3.38
Material fit	1	4.27 (0.93)	–	4.37
Engagement fit	1	4.37 (0.89)	–	4.19
Assessment fit	1	4.31 (0.92)	–	4.54
Course technology	3	–	0.81	1.97/2.60
Support	1	4.16 (0.97)	–	1.67
Accessibility	1	4.20 (0.93)	–	2.30
Usability	1	4.21 (0.92)	–	1.81
Student satisfaction	3	–	0.95	–
Learning satisfaction	1	4.26 (1.02)	–	–
Participation satisfaction	1	4.27 (1.06)	–	–
Outcome satisfaction	1	4.37 (1.02)	–	–

Note: VIF - variance inflation factor. The coefficient alpha of online instruction and the descriptive statistics of its four dimensions were calculated based on their index scores (i.e. average scores of each construct's indicators). For online instruction and course technology, there are two VIF values: the first is for predicting instruction-technology fit and the second is for predicting student satisfaction.

model and single-factor model yielded the chi-squares of 154.48 and 428.88 at the degrees of freedom of 48 and 54, respectively. The difference test was highly significant ($\Delta\chi^2 = 274.40$, $\Delta df = 6$, p-value < 0.001), as model fit deteriorated dramatically from the four-factor model to the single-factor model. This suggests that four dimensions of online instruction are distinct from each other, and common method bias is not a big concern.

For other formative constructs, the reliability of their causal indicators was assessed (though internal consistency is not actually required), and all the coefficient alphas were above 0.7. For a reflective construct, this indicates consistently high factor loadings. For a formative construct, however, the significance levels of its causal indicators may vary depending on their effects on subsequent outcome variable(s) (Franke, Preacher, & Rigdon, 2008).

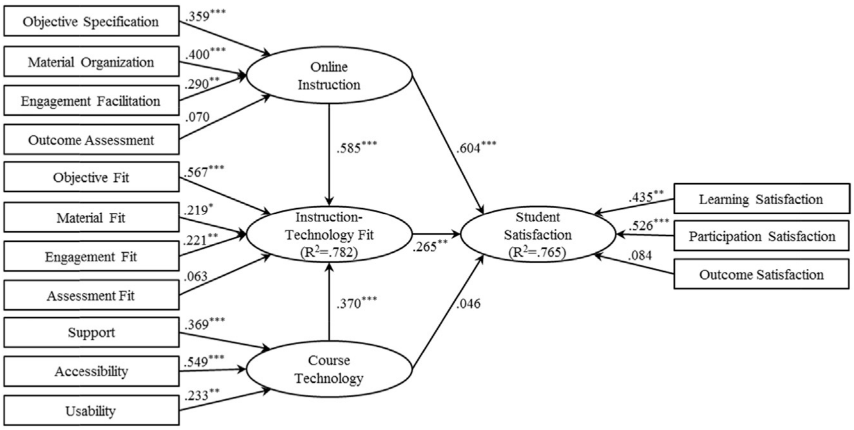
The testing of the research model requires structural equation modeling (SEM) as it involves both direct and mediating relationships among latent variables. Partial least square (PLS) analysis is known for its capability to handle formative latent variables in comparison with covariance-based SEM (Hair, Black, Babin & Anderson, 2013). In the research model, all the constructs are formative, and PLS is well suited for the purpose of model estimation. The SmartPLS3.0 program (Ringle, Wende, & Becker, 2015) that this study adopted uses the PLS algorithm to generate regression weights and the bootstrapping algorithm to estimate their standard errors.

Similar to multiple regression, PLS requires that explanatory latent variables not be highly correlated with each other. When they are formative, the collinearity among causal indicators needs to be examined as well. Both types of collinearity can be assessed with inner variance inflation factors (VIFs) associated with explanatory latent variables and outer VIFs associated with their causal indicators (Hair et al., 2013). Reported in Table 4, all the VIF values were below the threshold of 5 for salient collinearity (O'brien, 2007).

Fig. 3 shows the standardized regression weight of each structural relationship in the research model. The significance of a path is based on the t statistic in terms of the ratio between a coefficient and its estimated standard error. Most of the estimates were significantly positive as hypothesized. For the dependent variable student satisfaction, all its indicators but outcome satisfaction were significant. Among the indicators of online instruction, outcome assessment was the only one that was not significant. Similarly, assessment fit was the sole insignificant indicator of instruction-technology fit. Finally, all course technology indicators were significant.

Regarding the relationships among the latent variables, all of them were significant except for the path between course technology and student satisfaction. Partial mediation requires that both direct and indirect paths are significant, but full mediation is present when only the indirect path is significant (Hair et al., 2009). Therefore, the results suggested partial mediation for online instruction but full mediation for course technology. That is, instruction-technology fit carried the majority of course technology's influence on student satisfaction. For online instruction, however, its total effect on student satisfaction was more evenly shared between their direct path and indirect path through instruction-technology fit.

To further verify mediating relationships, this study conducted additional analyses as shown in Table 5. A mediating relationship requires the following conditions: 1) if the mediator is not present, the direct path between the independent and dependent variables in question is significant; 2) if the mediator is added, the direct path becomes less significant but the indirect path through the mediator is significant (Hair et al., 2009). In this study, when instruction-technology fit was removed from the model, both the direct paths between online instruction and student satisfaction and between course technology and student satisfaction were significant. In the full model with the mediator, however, only the direct path



Note: * - p<0.05; ** - p< 0.01; *** - p<0.001

Fig. 3. Model estimates.

between online instruction and student satisfaction remained significant but that between course technology and student satisfaction became insignificant.

The above method examines the importance of mediator when it is added. Compared with such an additive approach, the reductive approach removes the direct path in question and examines the impact on model fit (Chin, Marcolin, & Newsted, 2003). If the model fit deteriorates significantly, it suggests partial mediation because the direct path is still important. If the model fit does not change much, it suggests full mediation since the direct path can be ignored. Further validation of the partial and full mediations involving online instruction and course technology, therefore, was carried out by removing one direct path at a time. The impact on model fit as indicated by pseudo *F* test in Table 5 indicated that the direct path associated with online instruction was significant, but it was not the case for course technology. All the results, therefore, point to the partial mediation between online instruction and student satisfaction and the full mediation between course technology and student satisfaction.

Table 6 summarizes the results of hypothesis testing. For the relationships among latent variables, all the hypotheses were fully supported except for the one regarding the effect of course technology on student satisfaction. In the complete research model, the path was not significant. When the mediator of instructor-technology fit was not present, however, the direct effect of course technology on student satisfaction became significant. Thus, the result is mixed in that course technology has an indirect impact on student satisfaction through the mediation of instructor-technology fit. For the hypothesized relationships between latent variables and their indicators, most were supported except for those associated with outcome assessment.

It can hardly be a coincidence that all assessment-related indicators were insignificant for online instruction, instruction-technology fit and student satisfaction. Outcome assessment is obviously very important for online courses in terms of learning stimulation and goal achievement (Zlatović, Balaban, & Kermek, 2015). As indicated by the descriptive statistics in Table 4, outcome assessment and outcome Satisfaction had the highest average responses among all the indicators of online instruction and student satisfaction, respectively. It is probable that students are generally satisfied with outcome assessment in online courses due to the use of comprehensive gradebook, computerized testing and grading rubrics that make it relatively transparent and standardized. The insignificance of assessment-related indicators may be due to the lack of variation in the responses to relevant measures.

The results suggest that for other aspects of online instruction, course technology makes more salient differences. Instruction-technology fit fully mediated the effect of course technology and partially mediated the effect of online instruction on student satisfaction. The full mediation indicates that course technology influences student satisfaction mainly through the support it provides to online instruction rather than by itself. Meanwhile, the partial mediation suggests that online instruction needs the facilitation of course technology to reach its full potential. The real question is how to achieve better alignment between online instruction and course technology, which will be discussed in the next section along with other implications.

6. Conclusion and implications

This study examines the multi-dimensional alignment between online instruction and course technology, and investigates its relationships with related constructs. The results of an empirical study support most of the hypothesized relationships and provide some interesting findings regarding the different mediating roles that instructor-technology fit plays for online instruction and course technology in terms of their effects on student satisfaction. Highlighting the importance of course

Table 5
Mediated effects on student satisfaction through instruction-technology fit.

Approach	Estimate	Online instruction	Course technology
Additive	Direct path without mediator	0.751**	0.158*
	Direct path with mediator	0.604**	0.046
Reductive	R^2 of complete model	0.765	0.765
	R^2 of nested model (no direct path)	0.663	0.764
	f^2 value	0.434043	0.004255
	Pseudo F (1,214)	92.895**	0.911
	Conclusion	**Partial mediation**	**Full mediation**

Note: * - Significant at 0.05 level; ** - Significant at 0.01 level.

technology to online instruction, the findings also suggest that there is more space for instructors to maneuver for some aspects of alignment (e.g. engagement facilitation) than for others (e.g. outcome assessment) in course development.

One major limitation of this study is the lack of discipline representation in the sample. The online courses from which student participants were elicited were all in business and social science fields. It is possible that the online courses in other fields have unique characteristics, and the findings of this study may not be directly applicable to them. This limits the generalizability of specific findings, though the general findings regarding the relationships among online instruction, course technology, instruction-technology fit and student satisfaction may still hold. In future studies, observations can be collected from online courses in other fields to verify the findings and make cross-disciplinary comparisons. In addition to the survey design, experimental studies may provide further insights by manipulating the alignment between online instruction and course technology, such as using different e-learning tools for a certain type of learning activities.

Nevertheless, this study has some important theoretical and practical implications. First of all, it extends the concept of task-technology fit (TTF) to the context of online education. Due to the leaner-centered emphasis in educational context, it is not very helpful to directly borrow the existing TTF model to the evaluation of online courses. Compared with the original fit-as-matching conceptualization, this study follows the fit-as-gestalt and fit-as-mediation approaches to develop the instruction-technology fit construct and hypothesize its relationships with other constructs.

The fit-as-gestalt approach leads to the use of formative constructs to capture student perceptions of instruction-technology fit as well as other closely-related variables. Formative modeling provides the insights regarding which dimensions of each construct deserve closer attention for enhancing student learning experiences, otherwise unavailable with reflective modeling. In this study, for example, the assessment-related dimensions of online instruction, instruction-technology fit and student satisfaction were found to be insignificant. Meanwhile, the reliability coefficients of these constructs were relatively high (over 0.8), and in reflective modeling, the factor loadings of these indicators would still be all significant. Thus, formative modeling makes it possible to differentiate the contributions of different dimensions to the influence of each construct on the outcome variable (i.e. student satisfaction in this study).

Rather than being the sole predictor as in the original TTF model, instruction-technology fit mediates the effects of online instruction and course technology on the outcome variable of student satisfaction. Such a fit-as-mediation approach examines both the direct and indirect relationships involved, which leads to interesting insights. In this study, for instance, instruction-technology fit was found a full mediator for course technology but a partial mediator for online instruction. This indicated that the alignment was a necessary and sufficient condition for course technology to take full effects on student satisfaction, yet a necessary but not sufficient condition for online instruction. In other course settings, it is possible that such mediating relationships vary in strengths. For online courses that utilize technology extensively, for instance, it is possible that a full mediation may be found for online instruction as well. In future studies, therefore, such course characteristics may be observed and controlled to compare the results across different online courses.

For empirical analyses, this study adapts the QM Rubric items to measure student perceptions of online instruction, course technology and instruction-technology fit. The scales give researchers and practitioners an instrument to assess online course design and delivery from the leaner-centered perspective. As one of the most comprehensive frameworks that evaluate online courses, QM Rubric provides a sound foundation for measurement development. As all the indicators are causal for formative constructs, their measurement validation requires distinct criteria from that of reflective measures. Nevertheless, the results of descriptive and reliability analyses, common method bias and collinearity diagnoses and PLS estimation are all supportive of measurement validity for the theoretical relevance and conceptual completeness of all the dimensions within each construct.

This study focuses on the role that instruction-technology fit plays in online education, and the main practical implication concerns how to align course technology with online instruction. The descriptive statistics suggest that distance-learning students are least positive with course technology. Compared with face-to-face instruction, online instruction is more challenging due to extra technological layers, among other factors. The findings suggest that course technology is still perceived as a weak link despite its importance in supporting online instruction. Online course developers need to strengthen the support, accessibility and usability of course technology and align them with various aspects of online instruction. For certain learning activities (e.g. group projects), instructors may provide students with some autonomy by allowing them to choose e-learning tools (e.g. discussion board, wiki, web conferencing) based on their preferences in context.

Table 6
Hypothesis testing results.

Label	Path	Conclusion
H0a	Learning satisfaction → Student satisfaction	Supported
H0b	Participation satisfaction → Student satisfaction	Supported
H0c	Outcome satisfaction → Student satisfaction	Not supported
H1	**Online instruction → Student satisfaction**	**Supported**
H1a	Objective specification → Online instruction	Supported
H1b	Material organization → Online instruction	Supported
H1c	Engagement facilitation → Online instruction	Supported
H1d	Outcome assessment → Online instruction	Not supported
H2	**Course technology → Student satisfaction**	**Mixed**
H2a	Support → Course technology	Supported
H2b	Accessibility → Course technology	Supported
H2c	Usability → Course technology	Supported
H3	**Instruction-technology fit → Student satisfaction**	**Supported**
H3a	Objective fit → Instruction-technology fit	Supported
H3b	Material fit → Instruction-technology fit	Supported
H3c	Engagement fit → Instruction-technology fit	Supported
H3d	Assessment fit → Instruction-technology fit	Not supported
H4	**Online instruction → Instruction-technology fit → Student satisfaction**	**Supported (Partial)**
H5	**Course technology → Instruction-technology fit → Student satisfaction**	**Supported (Full)**

Furthermore, the results indicated that participation satisfaction was the most important component of student satisfaction, yet the engagement-related dimensions of online instruction and instruction-technology fit did not contribute to its prediction as much as other salient dimensions. This suggests that active learning is critical for online course success, yet there is still a big space for improvement regarding the use of course technology to facilitate learner participation and interaction. The priority effort to enhance distance learning, therefore, should be devoted to better alignment between course technology and the engagement facilitation aspect of online instruction. An online course can become truly successful in terms of academic achievement when it involves students in active learning through the use of technologies like computer-mediated communication to enhance learner participation and interaction (Zheng & Warschauer, 2015).

Of course, course technology also supports other aspects of online instruction, but the choices of e-learning tools are relatively limited or even fixed. To support course materials, for instance, online course platforms (e.g. Blackboard) provide presentation tools specific to text, image, audio and video content. For outcome assessment, each type of assignments requires the use of a certain tool (e.g. multiple-choice question, essay). Such tool standardization explains the insignificance of assessment-related dimensions of online instruction, instruction-technology fit and student satisfaction found in this study.

Rather, instructors have more freedom to decide which e-learning tools to use for different types of learning activities. In particular, the emergence of social media, Web 2.0, and online social networking technologies gives rise to a variety of tools to facilitate collaborative learning (Dabbagh & Kitsantas, 2012; Hamid, Waycott, Kuria, & Chang, 2015). Tools like discussion forum are widely used in online courses for brain storming, knowledge construction, critical thinking, and skill argumentation (Gerosa, Filippo, Pimentel, Fuks, & Lucena, 2010; Loncar, Barret, & Liu, 2014; Topcu & Ubuz, 2008). The choice of tools in online course design largely depends on the process (e.g. synchronous vs. asynchronous) and purpose (e.g. conveyance vs. convergence) of computer-mediated communication (Sun & Wang, 2014). For instance, blogs are appropriate for sharing personal thoughts and schedules, instant messaging is suitable for exploring ideas, web conferencing (e.g. BlackBoard Collaborate and Wimba) is helpful for coordinating real-time teamwork, and wikis are good for compiling project reports. The exposure to such tools enables students to handle different tasks effectively in group projects and prepares them for future careers that often require teamwork.

Active learning may also involve individual hand-on exercises. In face-to-face classes, it is easier to arrange lab assignments for students. In the online environment, instructors need to be more innovative by employing technologies such as virtualization and second life to facilitate student participation and instructor assistance for such learning activities (De Freitas et al., 2010; Marsa-Maestre, De La Hoz, Gimenez-Guzman, & Lopez-Carmona, 2013). Based on the virtualization technology, for instance, an instructor may set up a virtual lab (e.g. a database server) on a remote desktop. Students may log in the platform from a distance and work on lab assignments. The provision of such virtual lab environment saves students the hassle to purchase, install and configure software by themselves. It also allows instructors to log in the same platform for trouble shooting when students encounter difficulties, as if they help students in physical labs.

As illustrated above, course technology has great potential to enhance online instruction, especially learner engagement. Thus, the alignment between online instruction and course technology is essential for distance and hybrid education to meet both challenges and opportunities. Different stakeholders need to work together to strengthen alignment and mitigate misalignment. Instructors and administrators may obtain first-hand feedback from students to improve the customization and support of e-learning tools for all kinds of learning activities. The collaborative and iterative process is conducive to instruction-technology fit and ultimate student success.

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