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Research paper

Exploring Factors associated with the implementation of student-centered instructional practices in U.S. classrooms

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HIGHLIGHTS

- Student-centered instructional practices hold potentials to cultivate students' 21st-century skills.
- Teachers who received PD in ICT were more likely to support ICT-enhanced and project-based learning.
- Teachers who received student feedback and assessed learning frequently tended to adopt more student-centered instruction.
- More research on individualized PD programs and student assessment systems is needed.

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ABSTRACT

This study explored school- and teacher-level factors associated with a higher probability of teachers' implementation of student-centered instructional practices. These practices include adaptive instruction and active teaching strategies that support learning enhanced by information communication technology (ICT), collaborative small-group learning, and project-based learning. We used data from the U.S. sample in the Teaching and Learning International Survey (TALIS) 2013, which consisted of 1112 teachers from 89 public schools. Results showed that teacher participating in professional development (PD) in ICT and approaches to individualized learning, receiving student feedback, and student assessments were related to a higher level of implementing student-centered instruction.

The need to prepare all students for technological, social, and learning demands of the 21st century supports momentum for increasing student-centeredness in education (Basham et al., 2020). While recent education reform efforts around the globe have turned to student-centered learning, most education systems are struggling to shift away from the standardized, one-size-fits-all model that fails to meet students' diverse needs (Zhao, 2016). Meanwhile, the rapid development and adoption of technological innovations, which define the complexity and unpredictability of the 21st century (Schwab, 2016), pose a challenge as to what skills are needed for students to succeed in the future (Reimers & Chung, 2016). To respond, researchers have begun to define the concept of 21st-century skills (Reimers & Chung, 2016). Drawing upon an analysis of eight frameworks describing 21st-century skills, Voogt and Roblin (2012) found common essential 21st-century skills include, but not limited to, collaboration, communication, information communication technology (ICT) literacy, and problem solving.

While the concept of 21st-century skills continues to emerge, there is less consensus regarding how teachers should prepare students for 21st-century learning. Researchers posited that instructional practices for supporting 21st-century learning usually take a more student-centered approach (Friedlaender et al., 2014; Ray, Sacks, & Twyman, 2017). As a broad educational concept, student-centered pedagogy has its roots in constructivist learning theories (see Bruner, 1961; Piaget, 1973; Vygotsky, 1978) and the progressive education movement in the early 20th century (see

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Dewey, 1938). In practice, student-centered approaches seek to deepen student learning by making learning meaningful, relevant, rigorous, and responsive to students' needs (Friedlaender et al., 2014). Additionally, students are provided multiple opportunities and ways to demonstrate mastery of knowledge and skills (Basham, Hall, Carter, & Stahl, 2016). The core concept of student-centeredness highlights learners' active roles in constructing knowledge and skills through actions in learning activities (Mascolo, 2009). Teachers, then, act as facilitators who understand how and why students are learning to guide students' self-directed and self-determined learning (Friedlaender et al., 2014; Wehmeyer, 2019).

1. How do student-centered practices support 21st-Century learning?

Student-centered learning can take different forms, but the existing literature has focused on how practices such as project-based learning, collaborative learning, and technology-enhanced learning operationalized student-centeredness (e.g., Bell, 2010; Chen, 2010; Chen & Yang, 2019; Lou, Abrami, & d; 'Apollonia, 2001). During project-based learning activities, students usually work in small groups to explore, create, and construct solutions through collaboration, communication, and guided reflection (Blumenfeld et al., 1991; Kokotsaki, Menzies, & Wiggins, 2016). A recent meta-analysis of project-based learning research conducted in nine countries revealed that student-centered instructional approaches yielded an overall medium-to-large mean effect size (0.71) on student achievement (Chen & Yang, 2019). Multiple studies suggested, project-based learning, if designed and implemented well, could also help develop students' metacognitive skills such as self-regulation (e.g., English & Kitsantas, 2013), increase motivation and interest (Blumenfeld et al., 1991), as well as foster higher-order thinking and problem-solving skills (Darling-Hammond, Flook, Cook-Harvey, Barron, & Osher, 2019).

Collaborative small group learning has demonstrated benefits for students in improving academic outcomes, self-concept, and social interaction skills (e.g., Ginsburg-Block, Rohrbeck, & Fantuzzo, 2006; Johnson, Johnson, & Stanne, 2000). Researchers suggested that small-group cooperation increased opportunities for students to engage in meaningful learning such as sharing original ideas, providing critique, and collaborating to generate strategies (Darling-Hammond et al., 2019). For both project-based and collaborative learning, factors such as innovative use of technology, supportive guidance and scaffolding, a balance between explicit instruction and in-depth inquiry methods, and thoughtful feedback have proven effective in facilitating student learning (Kokotsaki et al., 2016).

Among these factors, technology plays an increasing role in preparing all learners for the technology-infused 21st century. Extensive research has shown that only using technology for drill and practice, word processing, computer-based tutorials was ineffective in creating engaging learning experiences (Karich, Burns, & Maki, 2014). Instead, effective use of technology should engage students in exploring and expressing ideas, creating solutions, interacting with peers and experts, and/or other interactive learning activities (Chen, 2010; Robinson & Sebba, 2010). Such technology-enhanced learning experiences can help develop students' collaboration, communication, and critical thinking skills (U.S. Department of Education, 2017).

Overall, evidence has accumulated on the positive impact of the aforementioned student-centered practices on improving students' 21st-century skills. All learners, including students with disabilities and students from other marginalized groups, would benefit from better education opportunities that not only tailor learning to their needs but also help foster knowledge and skills essential for success in the 21st century (Wehmeyer, 2019; Zhao, 2012). This makes adapting instruction to individual learners' needs the central feature of a student-centered learning environment (Parsons et al., 2018; Parsons & Vaughn, 2016). Previous research has investigated the positive impact of adapting learning to learners' social, linguistic, cultural, and instructional needs on student academic and non-academic (e.g., agency, engagement) outcomes (see Hattie, 2009; Parsons et al., 2018). Nevertheless, there are few studies that explicitly reported on how adaptive instruction impacted students' 21st-century learning outcomes (Parsons et al., 2018).

2. Supporting student-centered practices in the U.S. Context

A recent study conducted by UNESCO (2016) documented an emergence of instructional practices that focus on promoting student-centered learning; however, it also indicated a lack of teacher training that would lead to better implementation of those practices across ten Asian-Pacific education systems. In the United States, an increasing number of districts have begun initiatives to shift their school systems toward more student-centered learning environments (U.S. Department of Education, 2015). Given the broadness of the current conceptualization of student-centered learning, instructional approaches may vary under specific contexts across schools (Burns & Darling-Hammond, 2014). Researchers suggested that an array of factors would lead to changes in student-centered instructional practices (Burns & Darling-Hammond, 2014; Chen, 2010). Some widely researched factors include policy implementation, curricula, assessment, quality PD, integration of technology, and constructive feedback on instruction (see Hattie, 2009; Pedersen & Liu, 2003).

As interest in preparing students for the 21st-century continues to grow, there is a need to investigate what factors would potentially support student-centered practices, which, in turn, facilitate 21st-century learning. In the present exploratory study, we use a secondary data set to investigate to what extent multiple school- and teacher-level factors impact teaching practices that have the potential to cultivate students' 21st-century skills. Specifically, we examined whether (a) school-level ability to provide instructional resources, teacher-centered professional development (PD) plans, and feedback on teaching as well as (b) teacher-level participation in various PD programs, receiving student feedback on teaching, and assessment practices in classrooms were associated with the implementation of more student-centered practices in U.S. classrooms. In the following sections, we briefly described these factors related to instructional support, provision and participation in PD, and feedback on classroom teaching and learning.

2.1. School-level instructional support

Systematic support at the school level is closely tied to educators' access to resources (e.g., instructional materials, PD) needed for improvement. Providing adequate instructional resources is essential for establishing a schooling environment conducive to effective teaching and learning (Burns & Darling-Hammond, 2014). For example, a previous study found that insufficient instructional resources in U.S. public schools resulted in lower participation rates of PD (Choy, Chen, Bugarin, & Broughman, 2006). Other school-level instructional leadership practices such as providing feedback on teaching and assigning a mentor to help improve instruction are also associated with the likelihood of changing instructional practices in classrooms (Kraft, Blazar, & Hogan, 2018; OECD, 2014a). However, there remains much to investigate on how to allocate school-level instructional resources and support to improve student-centered instructional practices and student outcomes.

2.2. Providing and participating in PD

Currently, most PD programs applied in schools still rely on outmoded approaches such as one-shot workshop or "sit and get" models that focus on training teachers in techniques that are not related to teachers' specific contexts and curriculum; therefore, they are less likely to yield long-term improvements (Darling-Hammond & Richardson, 2009; Reimers & Chung, 2016). Moreover, there is a lack of clarity of which type of PD is associated with a higher likelihood of implementing student-centered instruction. As educational reform efforts call for all learners to develop 21st-century skills, educators themselves need support that meets their diverse professional growth needs in designing student-centered instruction or flexible learning environments. Researchers have posited that providing individual PD plans to support teachers' diverse needs would improve their abilities as responsive and adaptive educators (see Sprott, 2019). Thus, more empirical evidence is needed to help understand whether the provision of individual PD plans and what combinations of varied PD programs would increase teachers' ability or tendency to implement more student-centered practices.

2.3. Improvement driven by data on teaching and learning

Previous research has reported that when receiving continued, constructive feedback on classroom teaching and learning from multiple stakeholder groups (e.g., administrators, students), teachers were more likely to improve teaching practices (Hattie & Timperley, 2007). Teachers' effective use of various data types collected at multiple points in time would inform practices such as adjusting instruction for the whole class, dividing students into small groups, tailoring instruction for individual students, and customizing feedback for student learning (see Friedlaender et al., 2014; Marsh, Pane, & Hamilton, 2006). Additionally, student feedback on teaching has emerged as an important data source that schools and teachers can use to improve instructional designs in U.S. K-12 educational settings (Ferguson, 2012). Yet, questions remain as to whether incorporating feedback on teaching and learning would impact educators' tendency to implement instructional practices that better support student-centered learning.

3. The current study

As noted above, extensive research has shown enhanced learning outcomes are associated with various student-centered instructional strategies such as adaptive teaching (see Parsons et al., 2018), technology-enhanced learning (see Chen, 2010), collaborative small group learning (see Johnson et al., 2000; Lou, Abrami, & d'Apollonia, 2001), and project-based learning (see Chen & Yang, 2019; Kokotsaki et al., 2016). However, research investigating factors at different levels (e.g., school, teacher) that might impact student-centered instructional practices in classrooms with a diverse student population is lacking.

In this study, we used the nationally representative data that were collected from the U.S. results of the 2013 administration of the Teaching and Learning International Survey (TALIS) to explore teachers' implementation of student-centered instructional practices. Coordinated by the OECD, TALIS is designed to measure lower secondary education (i.e., grades 7 to 9) principles' and teachers' perceptions of the teaching conditions and learning environments of schools in participating countries every five years (Strizek, Tourkin, & Erberber, 2014). TALIS 2013 provided information pertaining to teachers' implementation of student-centered instructional practices, including adaptive instruction and active teaching strategies that support ICT-enhanced learning, collaborative small group learning, and project-based learning (Burns & Darling-Hammond, 2014; see a more detailed description of these strategies in the Method section). The purpose of the current study is to examine associations between different school -and teacher-level factors and the frequency with which a teacher adopted the aforementioned strategies in their classrooms. Specifically, this study aims to explore the following questions:

1) Does the frequency of teachers' implementation of more student-centered instructional practices vary across U.S. lower secondary education schools?
2) To what extent is school-level support for instruction associated with a higher frequency of teachers' implementation of student-centered instructional practices?
3) To what extent are teachers' participation in different PD programs, receipt of student feedback, use of student assessment, proportion of diverse learners in classroom associated with a higher frequency of teachers' implementation of student-centered instructional practices?

4. Method

4.1. Data

TALIS 2013 consists of the teacher and principal questionnaires. Detailed information on the development and validation of the questionnaires can be found in TALIS 2013 Technical Report (OECD, 2014b). TALIS 2013 was administered to school principals and up to 20 teachers in 200 lower secondary schools from 34 participating countries. Data used in this study are from the U.S. administration of TALIS 2013. Conducted by the National Center for Education Statistics of the Institute of Education Sciences, the U.S. TALIS 2013 followed a stratified two-stage probability sampling design (Strizek et al., 2014). This method ensured the national representativeness of the sample by first systematically selecting schools with probability proportional to size from the stratified sampling frame and then randomly selecting teachers within the sample schools (Lumley, 2004).

4.2. Participants

Originally, 152 U.S. public and private lower secondary schools participated in TALIS 2013, with 122 schools having 50 percent or more response among teachers (Strizek et al., 2014). We limited the analysis to the 122 schools, and less than 20% of the sample was reduced. We further limited the analysis to 89 public schools in which principals and 1515 teachers were surveyed. Another inclusion criterion is that we only included teachers who reported teaching practices in a target classroom, which refers to the classroom that is not directed entirely or mainly to students with special needs[1] and representative of all the classrooms they teach. This inclusion criterion allowed us to explore factors that would influence teachers' instructional strategies in a more inclusive education setting where a heterogeneous population of students were enrolled. After applying this criterion, the sample dropped to 1193

[1] Students with special needs are defined as those who have a special learning need that has been formally identified due to mental, physical, or emotional characteristics in TALIS.

teacher participants. In addition, we excluded 81 teachers who provided no information on PD. As a result, the final sample consists of 1112 teachers from 89 public schools. The number of teachers in each school ranges from 3 to 21, with a mean of 12.5. Only three schools have less than five teachers participating in the study.

4.3. Dependent variables

We explored the frequency with which the participating teachers implemented four student-centered instructional approaches in their target classroom. These approaches include adapting instruction, ICT-supported learning, collaborative small-group learning, and project-based learning.[2] All these approaches were commonly considered to be more student-centered instructional designs. The last three approaches were identified as active teaching practices in TALIS, which have the potential for supporting students in becoming more self-initiating and engaged in learning (Burns & Darling-Hammond, 2014; OECD, 2014a).

Specifically, the information pertaining to the four instructional approaches was gathered on teachers' responses to the survey scale "How often does each of the following happen in the target class throughout the school year?" Teachers responded to four items investigating the frequency with which they "*give different work to the students who have difficulties learning and/or to those who can advance faster,*" "*students use information and communication technology (ICT) for projects or class work,*" "*students work in small groups to come up with a joint solution to a problem or task,*" or "*students work on projects that require at least one week to complete.*" Teachers rated the four items with four response categories, which are "never or nearly never," "occasionally," "frequently," and "in all or nearly all lessons."

4.4. Independent variables

We used different school- and teacher-level factors including instructional resources, instructional supports, professional training, student feedback, use of student assessments, and proportion of diverse learners in target classrooms as predictors to examine the frequency of implementing each instructional approach.

4.4.1. School-level variables

Shortage of instructional resources was included as a school-level factor. TALIS asked principals to rate on five items gathering information on the extent to which they thought the school's capacity to provide quality instruction was hindered by a shortage of instructional resources. These resources include instructional materials (e.g., textbooks), computers for instruction, Internet access, computer software for instruction, and library materials. The ratings were measured on a 4-point Likert scale with 1 for "strongly disagree", 2 for "disagree," 3 for "agree," and 4 for "strong agree." In this study, we created insufficient instructional resources as a composite variable. The scores were obtained by aggregating principals' ratings on the five items.

Additionally, information on whether the participating schools provided teachers with instructional supports following a teacher appraisal was collected through three discrete items. These supports were measured by principals' estimates on how frequently discussing with teachers about measures to remedy any weakness in teaching, developing a PD plan for each teacher, and appointing a mentor to help teachers improve instruction occurred in their school. The original estimates were measured on an ordinal variable with four response categories: 1 for "never," 2 for "sometimes," 3 for "most of the time," and 4 for "always." Due to the low response rate on the first two categories for each estimate, we grouped the two lower levels and the two higher levels into two categories, which formed a binary variable with 0 for "low frequency" and 1 for "high frequency."

4.4.2. Teacher-level variables

The first group of teacher-level variables provided information regarding teachers' participation in various PD programs. Teachers reported whether they participated in PD in student assessment, ICT skills for teaching, approaches to individualized learning, teaching students with special needs, teaching in a multicultural setting, and teaching cross-curricular skills (e.g., problem solving, learning to learn) by responding "Yes" or "No." We coded "No" with "0" to indicate non-participation in PD and "Yes" with "1" to indicate participation. The second teacher-level factor concerned student feedback on teachers' instruction. It was measured by teachers' responses to one ITALIS item asking them whether they received student feedback. We coded "0" or "1" to indicate that teachers have never or have received such feedback.

In addition, we created teachers' use of student assessment as a composite variable. The scores were obtained by aggregating teachers' responses to the six items that were designed to measure the extent to which they used different assessment methods to assess student learning in their target class. These methods include teacher-created assessment, standardized tests, questions posed to individual students, written feedback on student work, student self-evaluation of their own progress, and immediate feedback on student tasks. The responses were expressed on a 4-point scale with 1 for "never or almost never" to 4 for "in all or nearly all lessons."

The last teacher-level variable is the estimated proportion of diverse learners (including ELLs, low academic achievers, students with special needs, students with behavioral challenges, students from low-SES backgrounds, and gifted students) in teachers' target classrooms. Teachers rated six discrete 5-point Likert items with 1 for "none," 2 for "1%–10%," 3 for "11%–30%," 4 for "31%–60%," and 5 for "more than 60%." To calculate the aggregated percentage of diverse learners, we first combined each principal's rates on the six items and then coded the aggregated number that fell between 1 and 6 as "None," 7 to 12 as "1%–10%," 13 to 18 as "11%–30%," 19 to 24 as "31%–60%," and 25 to 30 as "more than 60%." Therefore, proportion of diverse learners remains to be an ordinal variable. Table 1 provides name, coding schemes, and descriptive statistics of all variables included in this study. All items selected for this study demonstrate strong reliability, the details of which can be found in the TALIS technical report (OECD, 2014b).

4.5. Data analysis

Given that teachers who responded to the survey were nested within schools, we used multilevel ordinal regression models (Hox, 2010) to estimate relationships between teacher-related (level 1) factors or school-related factors (level 2) and the frequency of

[2] To explore whether student-centered instructional practices operationalize as a correlated manifestation of a latent construct, we conducted a correlation analysis to estimate the intercorrelations among these variables. The results show the correlation among these variables ranges from 0.19 to 0.39, with a Cronbach alpha of 0.58. The strongest correlation exists between ICT-enhanced learning and project-based learning. However, an overall week correlation exists among variables. We proceeded to conduct a factor analysis in an effort to build a latent construct of student-centered instructional practices. The results showed that loading factors ranged from 0.318 to 0.548, which indicates a week model for the latent variable. In this regard, we believe that considering these practices as distinct a manifestation of student-centered instruction generated a more accurate interpretation of the results from the present study.

Table 1
Names, coding schemes, and descriptive statistics of dependent and independent variables.

Dependent Variable	TALIS Data Sources	
	Coding Scheme	Descriptive Statistics
Adaptive instruction	1 = Never or nearly never, 2 = occasionally, 3 = frequently, 4 = in all or nearly all lessons	1 = 14.75%, 2 = 45.86%, 3 = 29.50%, 4 = 8.45%, MD = 1.44%
ICT-enhanced learning	1 = Never or nearly never, 2 = occasionally, 3 = frequently, 4 = in all or nearly all lessons	1 = 17.90%, 2 = 40.91%, 3 = 30.94%, 4 = 8.99%, MD = 1.26%
Small-group learning	1 = Never or nearly never, 2 = occasionally, 3 = frequently, 4 = in all or nearly all lessons	1 = 7.10%, 2 = 37.41%, 3 = 41.64%, 4 = 12.59%, MD = 1.26%
Project-based learning	1 = Never or nearly never, 2 = occasionally, 3 = frequently, 4 = in all or nearly all lessons	1 = 21.31%, 2 = 43.44%, 3 = 22.84%, 4 = 11.15%, MD = 1.26%
School-Level Variables		
Inadequacy of instructional materials	It was converted into a continuous variable	M = 9.744; SD = 3.57
Follow-up instructional supports		
Remedying teaching weakness	0 = Low frequency; 1 = High frequency	0 = 18.62%, 1 = 81.38%
Providing individual PD plan	0 = Low frequency; 1 = High frequency	0 = 57.01%, 1 = 42.99%
Mentoring teaching	0 = Low frequency; 1 = High frequency	0 = 67.09%, 1 = 32.91%
Teacher-Level Variables		
Professional training		
Student assessment	0 = Never participated, 1 = Participated	0 = 27.52%, 1 = 72.48%
ICT skills for teaching	0 = Never participated, 1 = Participated	0 = 50.90%, 1 = 49.10%
Individualized learning	0 = Never participated, 1 = Participated	0 = 43.53%, 1 = 56.47%
Teaching students with special needs	0 = Never participated, 1 = Participated	0 = 65.47%, 1 = 34.53%
Teaching in multicultural setting	0 = Never participated, 1 = Participated	0 = 75.09%, 1 = 24.91%
Teaching cross-curricular skills	0 = Never participated, 1 = Participated	0 = 50.45%, 1 = 49.55%
Feedback from student surveys	1 = Not received, 2 = Received	1 = 71.4%, 2 = 25.54%, MD = 3.06%
Use of student Assessment	It was converted into a continuous variable	M = 16.08; SD = 2.59, MD = 1.71%
% of diverse learners in classroom	1 = None, 2 = 1%–10%, 3 = 11%–30%, 4 = 31%–60%, 5 = More than 60%	1 = 0.09%, 2 = 17.63%, 3 = 60.97%, 4 = 19.78%, 5 = 0.54% MD = 1.00%

Note. TALIS = Teaching and Learning International Survey; ICT = Information and Communication Technology; M = Mean; SD = Standard Deviation; MD denotes the percentage of missing data.

teachers' implementation of more student-centered instructional approaches. Multilevel modelling is viewed as an appropriate statistical technique to analyze nested data (Raudenbush & Bryk, 2002). The ordinal regression models were chosen to estimate the probability that each independent variable falls into a higher value of an ordinal dependent variable. The equation for a two-level logistic model to examine the frequency of implementing each instructional approach using a logit link function was estimated as follows:

$$\eta_{ijc} = logit(P^*_{ijc}) = \ln(\frac{P^*_{ijc}}{1-P^*_{ijc}}) = Y_{00} + \sum_{m=1}^{m} Y_{mj} X_{ij} + \sum_{n=1}^{n} Y_{0n} Z_j + \theta_c + \mu_{0j},$$

where c = 1, 2, 3.

In each logistic model, P^*_{ijc} is the cumulative probability up to the c-th category that a teacher would adapt instructions, allow students to use ICT, support small-group work, or facilitate project-based learning in target classroom i in school j. θ_c is a threshold relating to the probabilities that teachers responded to each category across the j schools. In our analysis, three thresholds (i.e., $C = 3$) parameters were estimated in each model. In addition, X_{ij} and Z_j denote that m teacher-level variables and n school-level variables were measured, respectively. Therefore, the fixed coefficient $Y_{00} + \theta_1$ is the average threshold for $c = 1$ to $c = 2$, $Y_{00} + \theta_2$ is for $c = 2$ to $c = 3$, and $Y_{00} + \theta_3$ is for $c = 3$ to $c = 4$ across schools. The random effect u_{0j} denotes school-level residual variance. Both Y_{00} and u_{0j} are assumed to follow a normal distribution with a mean of 0 and a variance of $\pi^2/3 = 3.29$.

To address the three questions, we used an exploratory top-down procedure (Sommet & Morselli, 2017) to estimate the ordinal logistic models for each dependent variable. The first step started with estimating an unconditional model to examine the proportion of variance in the frequency of implementing each approach accounted for by unexplained school-level factors. Results from this step helped address the first research question as to whether the frequency of implementing student-centered instructional practices varied across schools. The second step estimated a full model wherein all teacher-level and school-level predictors were included. Likelihood ratio tests were used to assess whether removing the random effects from the full model worsened the model fit. In addition, a set of likelihood ratio tests were conducted to compare the goodness of fit of two nested models (i.e., a reference model against an alternative model excluding one predictor from the reference model) to estimate the significance of different fixed effects. Results from this step helped address the second and third research questions as to which school- and teacher-level variables were associated with the frequency of implementing each student-centered practice.

In the third step, a model excluding statistically insignificant predictors was estimated. The Y coefficients yielded from the two-level models were transferred into odd ratios to denote the cumulative probabilities up to each category of teachers' response of implementing the four instructional practices accounted for by the changes in the predictors. The analysis in this step helped examine the extent to which the significant school- and teacher-level variables were associated with the frequency of implementing student-centered practices. All data were analyzed within R version 3.4.1 using the clmm package (R Core Team, 2017). Listwise deletion method was applied to handle the missing data given that less than 2% of missingness was detected for each of those variables that contained missing values (see Table 1).

5. Results

Table 2 shows the results of the ordinal logistic models for the four dependent variables. The intraclass correlation (ICC) estimated by the unconditional model for each approach is $\rho = 0.073$, 0.080, 0.075, and 0.027, respectively. This suggests that 7.3%, 8.0%, 7.5%, and 2.7% of the total variance in the frequency of adapting instruction, supporting students in using ICT, allowing for small-group work, or facilitating project-based learning existed between the participating schools. The likelihood ratio tests comparing the full model and the alternative model excluding the random intercept generated deviance $LR\,\chi^2 = 20.93(df = 1, p < .001)$ for adaptive instruction, $LR\,\chi^2 = 23.14(df = 1, p < .001)$ for ICT use, $LR\,\chi^2 = 18.24(df = 1, p < .001)$ for small group learning, and $LR\,\chi^2 = 3.36(df = 1, p = .19)$ for project-based learning.

The results of likelihood ratio tests suggested that significant

Table 2
Multilevel ordinal models predicating higher possibilities of implementing student-centered instructional practices.

	Unconditional Models				Full Models				Final Models			
	AI	ICT	SG	PBL	AI	ICT	SG	PBL	AI	ICT	SG	PBL
	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)	γ (SE)
Fixed Effects												
School-level												
Inadequate instructional materials						− 0.05* **(0.02)**				− 0.04* **(0.02)**		
Remedying teaching weakness												− 0.32* **(0.14)**
Providing individual PD plan												
Assigning mentor to teacher							−0.32. (0.18)					
Teacher-level												
PD in student assessment												
PD in ICT skills for teaching						0.68*** **(0.13)**		0.26* **(0.12)**		0.71*** **(0.12)**		0.29** **(0.11)**
PD in individualized learning					0.25 (0.14)		0.47*** **(0.14)**		0.34** **(0.12)**		0.37*** **(0.12)**	
PD in teaching SWD							-0.29* **(0.14)**					
PD in teaching multiculturally												
PD in cross-curricular skills												
Feedback from student survey					0.47*** **(0.14)**	0.38** **(0.13)**	0.31* **(0.14)**	0.26* **(0.13)**	0.49*** **(0.14)**	0.42** **(0.13)**	0.30* **(0.14)**	0.28* **(0.13)**
Use of student assessment					0.18*** **(0.02)**	0.12*** **(0.02)**	0.22*** **(0.12)**	0.17*** **(0.02)**	0.67*** **(0.12)**	0.12*** **(0.02)**	0.22*** **(0.02)**	0.18*** **(0.02)**
Fixed Effects												
Teacher-level												
% of diverse learners												
11%–30%					0.70*** **(0.17)**			0.29. (0.15)	0.69*** **(0.17)**			
31%–60%					1.29*** **(0.21)**				1.30*** **(0.21)**			
More than 60%												
Thresholds												
θ_1	−1.85 (0.11)				2.20 (0.49)	.054 (0.46)	0.75 (0.47)	1.47 (0.42)	1.96 (0.41)	0.35 (0.42)	0.98 (0.39)	1.62 (0.39)
θ_2	0.47 (0.08)				4.70 (0.51)	2.66 (0.47)	3.37 (0.48)	3.52 (0.43)	4.45 (0.43)	2.46 (0.43)	3.59 (0.39)	3.66 (0.40)
θ_3	2.45 (0.12)				6.85 (0.53)	4.75 (0.49)	5.74 (0.50)	4.99 (0.45)	6.59 (0.45)	4.5 (0.45)	5.95 (0.42)	5.13 (0.42)
Random Effects (σ^2)												
Var. in Intercept	0.26*** (0.51)	0.29*** (0.54)	0.27*** (0.52)		0.20*** (0.45)	0.17** (0.42)	0.15** (0.39)		0.20** (0.45)	0.17** (0.41)	0.18** (0.42)	
ICC	0.073	0.080	0.075	0.027	0.058	0.050	0.045	NA	0.058	0.049	0.05	NA
Observations	1096	1098	1098	1112	1088	1090	1089	1093	1088	1090	1089	1093
Model fit												
LogLik	−1318	−1368	−1291	−1476	−1237	−1307	−1216	−1358	−1237	−1307	−1216	−1363
$LR\,\chi^2$	20.93***	23.14***	18.24***	3.36	14.06***	9.04**	7.64**	0.78	5.81	11.34	14.00	NA

Note. *$p \le .05$, **$p \le .01$, ***$p \le .001$; SE = standard errors; AI = adaptive instruction; ICT = information communication technology; SG = small group; PBL = project-based learning; SWD = students with disabilities; PD = professional development; Var. = variance; NA = not applicable.

differences (i.e., $p < .005$) existed in implementation of adaptive instruction, ICT-enhanced learning, and small-group learning. To address our first research question, therefore, there is a significant difference in the frequency with which a teacher implemented the first three instructional approaches between U.S. lower secondary education public schools. Given that there is no significant difference (i.e., $p > .005$) in the frequency of facilitating project-based learning between schools, we used a single-level ordinal logistic model to estimate the association between the dependent and independent variables.

To address our second and third research questions, we reported the results of the final ordinal logistic model for each instructional approach, respectively, in the following section. As indicated above, the final models only included statistically significant predictors. To better interpret the results, we converted the coefficients of these predictors into odds ratios (OR) with 95% confidence intervals (see Table 3). As an index of effect size, odds ratios of 1.5, 2, and 3 are classified as small, medium, and large (Sullivan & Feinn, 2012). Overall, Table 3 shows that the effect size for the correlation between educators' participation in ICT and a higher likelihood of student use of ICT for class projects is considered as medium (OR = 2.04, 95% CI [1.61, 2.58]). Additionally, the effect size for the correlation between a higher enrollment of diverse learners (i.e., 11%–30%, 31%–60%) in class and a higher frequency of assigning different work to students with varying ability is considered as medium (OR = 2.00, 95% CI [1.45, 2.78]) or large (OR = 3.48, 95% CI [2.46, 5.60]). The effect sizes for other correlations in the final models are all considered as small.

5.1. Adapting instruction

Table 2 shows that the relationships between the school-level predictors and the frequency with which teachers would adapt instruction in their target classroom are statistically insignificant. However, there is the evidence of unobserved variance ($\sigma^2 = 0.20$, $p < .001$) in the frequency between schools. At the teacher level, there are statistically significant positive associations between teachers' participation in PD for teaching students with disabilities, receiving feedback from student surveys, use of student assessments, and teaching a class with a higher proportion (up to 60%) of diverse learners and the frequency with which they would give different work to students with diverse learning needs.

As indicated above, we interpreted the effects of predictors in the final ordinal model using the odds ratios for cumulative probabilities (Table 3). For example, for teachers who participated in PD in individualized learning, the odds of rating above "occasionally" (i.e., "frequently" or "in all or nearly all lessons") versus below or equal to "occasionally" (i.e., "occasionally" or "never or almost never") in terms of adapting instruction were 1.40 times greater than those who did not participate in the PD, controlling for other variables. Similarly, for teachers who received feedback from student surveys about their teaching, the odds of rating above "occasionally" versus below or equal to "occasionally" were 1.63 times greater than those who did not receive such feedback, holding all other variables constant. For one additional unit of student assessment a teacher conducted, the odds of the teacher responding "frequently" or "in all or nearly all lessons" versus "occasionally" or "never or almost never" were 1.20 times greater. Additionally, teachers were more likely to assign different work to students in a target classroom with a greater proportion of diverse learners. However, this result does not hold true for classes with an enrollment of more than 60% of diverse learners.

5.2. ICT-enhanced learning

Table 2 shows that a random intercept variance ($\sigma^2 = 0.17$, $p < .001$) in the frequency of students using ICT for class work exists between schools. Specifically, the frequency of student use ICT in classrooms is negatively associated with a shortage of instructional resources at the school level (OR = 0.96, 95% CI [0.92, 0.995]; see Table 3). This suggests that teachers from schools with adequate instructional resources were 1.04 times more likely to rate above "occasionally" versus below or equal to "occasionally" in terms of supporting students in using ICT for class project or work than those from schools with a shortage of instructional resources. However, the effect size for this correlation is considered to be very small.

At the teacher level, for those who participated in PD in ICT skills for teaching, received feedback from student surveys, and frequently used student assessments, they were more likely to support ICT-enhanced learning activities. Table 3 shows that teachers who received PD in ICT skills were 2.04 times more likely to rate above "occasionally" versus below or equal to "occasionally" regarding the frequency of students' use of ICT than those without the ICT training, holding all other variables constant. Meanwhile, teachers who received feedback from student surveys about their teaching are more likely to support ICT use in classrooms than those who did not receive such feedback (OR = 1.52, 95% CI [1.17, 1.97]). For one additional student assessment a teacher conducted, the odds of the teacher rating "frequently" or "in all or nearly all lessons" versus "occasionally" or "never or almost never" regarding students' ICT use were 1.13 times greater.

5.3. Collaborative small-group learning

Similarly, while the estimated school-level predictors have no

Table 3
Odds ratios and 95% confidence intervals (CI) for dependent variables.

Independent Variables	Odds Ratios 95% CI			
	AI	ICT	SG	PBL
Inadequate instructional resources		0.96 [0.92, 0.995]		
Remedying teaching weakness				0.72 [0.55, 0.96]
PD in ICT skills for teaching		2.04 [1.61, 2.58]		1.34 [1.07, 1.67]
PD in individualized learning	1.40 [1.06, 1.71]		1.45 [1.23, 2.03]	
PD in teaching SWD				
Feedback from student survey	1.63 [1.22, 2.10]	1.52 [1.17, 1.97]	1.35 [1.06, 1.81]	1.32 [1.03, 1.70]
Use of student assessment	1.20 [1.14, 1.26]	1.13 [1.08, 1.18]	1.24 [1.19, 1.31]	1.19 [1.14, 1.25]
11%–30% of diverse learners	2.00 [1.45, 2.78]			
31%–60% of diverse learners	3.48 [2.46, 5.60]			

Note. AI = adaptive instruction; ICT = information communication technology; SG = small group; PBL = project-based learning; SWD = students with disabilities; PD = professional development.

statistically significant associations with the frequency of students working in small groups, an unobserved variance ($\sigma^2 = 0.18$, $p < .001$; see Table 2) in the frequency is found at the school level. At the teacher level, teachers' participation in PD in individualized learning is positively associated with the frequency with which students would engage in small-group learning activities. Similar to the above instructional approaches, teachers who received feedback from student surveys (OR = 1.35, 95% CI [1.06, 1.81]; see Table 3) and who conducted student assessments more frequently (OR = 1.24, 95% CI [1.19, 1.31]) were more likely to support collaborative small group learning in their class.

5.4. Project-based learning

Table 2 also shows that there is no evidence of statistically significant variance in the frequency of teachers' implementation of project-based learning at the school level. However, the fixed effect of school-level instructional support (i.e., discuss with teachers about measures to remedy any weakness in teaching) is statistically significant (OR = 0.72, 95% CI [0.55, 0.96]; see Table 3). This suggests that teachers from schools with less discussions about how to remedy teaching weaknesses were 1.39 times more likely to rate above "occasionally" versus below or equal to "occasionally" in terms of engaging students in project-based learning than those from schools where school leaders discussed more with teachers about remedying teaching weaknesses.

Similar to the other three instructional approaches, teachers who received PD in ICT skills were 1.34 times greater to rate above "occasionally" versus below or equal to "occasionally" compared to those who did not participate in ICT training, holding other variables constant. The frequency of implementing project-based learning in classrooms were 32% greater for teachers who received feedback from student surveys about their teaching compared to those who did not receive such feedback. For one additional student assessment a teacher conducted, the odds of the teacher rating "frequently" or "in all or nearly all lessons" versus "occasionally" or "never or almost never" regarding project-based learning were 1.19 times greater.

6. Discussion

In this study, we conducted exploratory analyses to investigate various predictors associated with teachers' implementation of more student-centered instructional approaches in 89 U.S. lower secondary public schools. These approaches include adaptive instruction and active teaching strategies that support ICT-enhanced learning, collaborative small-group learning, and project-based learning. Unlike many previous studies that examined the effects of teacher traits or characteristics (e.g., demographics, self-efficacy, teaching belief) on instructional practices, this study focused more on the factors that are more sensitive to changes in practices, such as student feedback, student assessment, and participation in PD.

Overall, we found evidence of heterogeneity in frequency of adapting instruction and implementing ICT-enhanced learning and small-group learning between the participating schools. We also found evidence of less frequent implementation of ICT-enhanced or project-based learning due to a shortage of instructional resources (i.e., instructional materials, computers for instruction, Internet access, computer software for instruction, library materials) or more discussions on how to remedy teaching weakness at the school level. Nevertheless, teacher-level variables including professional training, student feedback, and student assessments demonstrated more statistically significant associations with teachers' tendency to implement student-centered instructional practices. To inform future research, practice, and policy, we discussed the emerging patterns from the results that could inform the establishment of student-centered learning environments.

6.1. Integrating student assessment and feedback on teaching in learning environments

One pattern found in this study was that frequent use of student assessments significantly increased the possibility that a teacher would implement the four student-centered instructional approaches. This result affirms the findings from previous research indicating that ongoing evaluation of student learning serves as a key element in supporting student-centered learning (see Basham et al., 2016; Darling-Hammond & Richardson, 2009). In particular, a majority of student assessments surveyed by TALIS 2013 were considered to be formative assessments such as posing questions, providing feedback on student work, and supporting students' self-assessment. Compared to summative assessments such as standardized testing, formative assessments are more sensitive to specific contexts and instructional goals, enabling teachers to progress monitor how and what students are learning as well as activating students as the owners of their own learning (Black & Wiliam, 2009; Nicol & Macfarlane-Dick, 2006).

As such, our findings indicate that integrating multiple data resources, especially formative assessments, could help inform decisions toward establishing student-centeredness. However, we found teacher participation in PD in student assessment was not associated with a higher level of student-centered instruction. As we were unable to identify the types of assessments targeted by those PD programs because those data were not available through TALIS 2013, future research can focus on examining what and how PD would improve teachers' formative assessment practices that facilitate student-centered learning.

One promising finding from the present study was that teachers would be more likely to implement the four student-centered instructional practices if they received feedback from student surveys on teaching. Previous research has indicated that student ratings of teaching or their learning environment would predict learning outcomes (e.g., Lüdtke, Robitzsch, Trautwein, & Kunter, 2009). Our findings lend more support for incorporating student perceptions of teaching and/or learning as part of a data-driven decision-making system that would help educators design student-centered learning environments. Additionally, researchers suggested that offering students opportunities to provide feedback on instruction could potentially increase student voice in decision making associated with their own learning experience (Wallace, Kelcey, & Ruzek, 2016). Thus, our finding regarding student feedback helps substantiate that empowering student voice is essential to student-centered learning (Friedlaender et al., 2014; Patrick, Kennedy, & Powell, 2013).

As a tool to provide feedback on teaching and/or learning experience, student perception survey has gained traction in K-12 educational settings. Nevertheless, one potential challenge to use student feedback is that most education systems including the U.S. education system are heavily driven by accountability data on students, teachers, and schools (Bryk, Gomez, Grunow, & LeMahieu, 2015). This increases difficulty for incorporating student perception as part of school-level assessment systems. Thus, more research is needed to investigate effective ways in which educators could improve student feedback using validated measures and collect data that help inform improvements in student-centered instruction.

6.2. Professional training in supporting diverse learners for 21st-Century skills

Another pattern that emerged was teachers' participation in PD in ICT skills was positively associated with student use of ICT for class projects and project-based learning activities. These findings were consistent with the previous research that affirmed PD in ICT better prepared teachers to use technology-enhanced instruction to improve students' project-based learning and inquiry-oriented learning or other student-centered practices (see Gerard, Varma, Corliss, & Linn, 2011; Lawless & Pellegrino, 2007). We also found that participating in PD in individualized learning increased the frequency with which a teacher assigned different work to students with diverse needs or allowed students to work in small groups to come up with a solution to a question. However, there was no statistically significant relationship between teachers' participation in PD for teaching students with disabilities or other diverse learners such as those from multicultural backgrounds and the likelihood to implement any of the four student-centered instructional approaches.

These findings raised questions regarding how educators would benefit from participating in PD to support learning in truly inclusive, student-centered, and 21st-century learning environments. A previous literature review on PD research for inclusive education found that a majority of studies conceptualized inclusive education as concerned with changing instruction to address a single form of learner variability (e.g., ability difference; Waitoller & Artiles, 2013). Therefore, it is not surprising that our analysis found the more heterogeneous the student population was in a classroom, the more likely a teacher who reported participation in PD in individualized learning would assign different work to students.

However, it is important to note that emphasizing a single form of students' difference usually ignores the interaction of multiple factors (e.g., ability, ethnicity, language, gender) in forming learner variability (Waitoller & Artiles, 2013). In this regard, simply assigning different work to students based on their ability does not suffice to support learner variability, let alone help all learners with diverse needs develop essential 21st-century skills. More importantly, our study found that even participating in PD for teaching students with special needs or other diverse learners, educators were not likely to vary instruction to address a certain extent of learner variability or other student-centered practices to support student 21st-century learning.

Our findings also showed that participation in PD for teaching cross-curricular skills such as problem solving did not associate with more implementation of instructional approaches that support the development of 21st-century skills. This gives rise to several questions worthy of further discussion. For example, what PD programs could help improve educators' student-centered instructional practices for all learners, including students with disabilities and other diverse learners? What defines positive outcomes of implementing these instructional practices? Unfortunately, the TALIS 2013 data did not provide information on student academic learning outcomes in relation to 21st-century learning. Thus, it remains unclear whether students performed better in classrooms taught by teachers who were more likely to implement the four student-centered instructional practices. Moreover, regardless of an increasing expectation for improving student 21st-century skills, there is no consensus on which 21st-century skills to focus on, whether some serve as foundational skills, and how to balance between 21st-century skills and subject knowledge (Care & Kim, 2018). Therefore, more research is needed to conceptualize, validate, and operationalize assessments of implementing student-centered instructional practices in relation to students' 21st-century knowledge and skills.

Lastly, this study did not find a statistically significant association between providing individual PD plans at the school level and a higher possibility of teachers' implementing student-centered practices in classrooms. One possible explanation is that generally the individual PD plans provided by schools were not aimed at improving the four student-centered instructional practices analyzed in this study. Unfortunately, we were unable to identify the design nature of those individual PD plans in the present study. This prevented us from drawing further conclusions regarding whether those plans were designed to meet educators' professional learning needs or whether their needs were to implement more student-centered instructional practices. To better inform policy implementation, therefore, more research is needed to investigate whether individualized PD would better prepare educators for supporting learner variability, student-centeredness, and 21st-century learning.

6.3. Limitations and future directions

Although the findings of this study were promising there are limitations to be noted. First, the correlational nature of this study prevents us from drawing conclusions about causal relationships among the investigated variables. For example, in addition to the school- and teacher-level factors analyzed in this study, there may be other variables that could predict the implementation of student-centered practices. Thus, readers are advised to interpret the results with caution. Although correlational, this study contributes to a better understanding of which instructional support and practices related to a higher level of student-centeredness across the four instructional practices. The findings also provide implications for balancing efforts and resources on factors that would promote student-centered practices for facilitating 21st-century learning. It would be important to examine the causal relationships among these variables with experimental or quasi-experimental designs in future research.

Second, the data used in this study were from self-report surveys. There might be some potential threats (e.g., selection bias, respondents unknowingly providing misleading ratings, respondents rating the items in a socially desirable way) to the validity that would weaken the intended inferences drawn from the data (Desimone & Le Floch, 2004). This limitation suggests that future research should consider replicating the findings with real-life classroom data including, but not limited to, data collected from observations or digital data tracking tools. We are also aware that the sample used in this study differed substantially from the initial TALIS sample, dropping from 155 to 89 schools after missing data were accounted for and inclusion criteria were applied. Thus, reduction in school and teacher samples potentially undermined the generalizability of the findings as nationally representative to the U.S. lower secondary classrooms. Therefore, continued research using larger sample sizes within the U.S. context and across other educational contexts is needed to explore the impact of cultural and policy factors as well as school and classroom environment factors on student-centered instruction.

Third, giving different work to students with diverse learning needs is only one aspect of adaptive instruction (see Parsons et al., 2018). Additionally, student-centered learning involves more than using ICT, working in small groups, and engaging in project-based learning. These variables were chosen because they emerged from our analysis of literature as the most illustrative student-centered instruction approaches. The broadness and complexity of student-centeredness require more research to investigate its fundamental design components and how varied components function in an integrated system to facilitate effective implementation. To advance further understanding and implementation, one interesting research area is to examine student-centered instruction as a theory-driven latent construct. For example, researchers are encouraged to investigate what and how different instructional practices are correlated or nested within a latent construct that manifests the core conception of student-centered instruction in future studies.

7. Conclusion

This study explored school- and teacher-level factors that were related to the frequency of implementing four student-centered instructional practices in U.S. lower secondary classrooms. The results demonstrated that teachers who participated in PD in ICT skills and individualized instruction, received student feedback on teaching, and frequently used student assessments in classrooms were more likely to implement a more student-centered instructional practice. The results provided useful indicators to inform researchers, policymakers, school leaders, and educators about shared concerns and promising educational approaches that are conducive to supporting the development of student 21st-century skills.

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The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this article.

Appendix A. Supplementary data

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