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Latent Class Analysis of K-12 Teachers' Barriers to Implementing OER

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Latent class analysis of K-12 teachers' barriers to implementing OER

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ABSTRACT

Open educational resources (OER) are a cost-effective alternative to traditional textbooks for K-12 teachers to provide differentiated instruction at a much lower cost. However, teachers have to overcome barriers to implement OER in their classrooms, especially if cultural and economic factors are considered. To help each teacher overcome individual barriers, a person-centered approach to understand teachers' barriers of implementing OER is needed yet absent. This research thus filled the gap by conducting a latent class analysis of teachers' profiles in terms of their barriers in using OER. The findings identified three types of teacher profiles and revealed how different profiles impact the effectiveness of OER in teaching and learning. This study provides significant implications for scholars and practitioners helping teachers overcome barriers in implementing OER in K-12 settings.

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open educational resources (OER); teachers; K-12 education; barriers; person-centered analysis

Introduction

K-12 education has seen an increasing need to shift from a one-size-fits-all model to differentiated instruction across the world (Dack, 2018; Smale-Jacobse et al., 2019). Textbooks have been a primary option for K-12 teachers to deliver prepackaged knowledge to their students (Jobrack, 2011), but whether textbooks allow each student to learn effectively has sparked increasing concerns (Kimmons, 2015). Textbook adoption is usually not the teachers' decision but is overseen by school districts (e.g., the United States of America [USA], Canada) or educational authorities (e.g., Mexico) (Adebayo, 2018; Kimmons, 2015). This limits teachers' capacity for personalizing their instruction as the content in the textbook may not fit their needs (Kimmons, 2016).

The rise of open educational resources (OER) has been envisioned as an opportunity for K-12 teachers to provide effective learning resources accessible to all students, especially to those who otherwise cannot afford expensive textbooks (Blomgren, 2018; Tang et al., 2020; Van Allen & Katz, 2019). OER are a broader descriptor of "learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others" (UNESCO, 2019). With OER, K-12 teachers have free access to high-quality educational resources and open licenses to manipulate these

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resources for personal needs (Blomgren, 2018; Jimes et al., 2013). Research has also indicated when K-12 teachers used OER in the class, students' academic achievement and motivations remained on the same level or even improved when compared to those of students using traditional textbooks (Hilton et al., 2019; Van Allen & Katz, 2019). Therefore, OER can be an alternative to textbooks for K-12 teachers to help each student learn effectively.

However, barriers still exist when teachers implement OER in K-12 settings (Kimmons, 2016; Ngimwa & Wilson, 2012; Tang, 2020). Research has indicated that internal barriers, such as teachers' lack of adequate technology skills, willingness, and pedagogical knowledge to integrate OER, thwart their use of OER. For example, Tang (2020) discussed that teachers in the USA felt it challenging to integrate OER and also difficult to become adept at searching and adapting OER appropriate for their courses. Ngimwa and Wilson (2012) argued that African preservice teachers were also concerned about using and producing OER because of their low computer literacy. In addition to personal barriers, teachers undergo external barriers beyond their control when using OER (Kimmons, 2016; Tang, 2020). Kimmons (2016) described external barriers that K-12 teachers in the USA encountered in two categories: macro barriers (i.e., barriers are out of the school districts' control to overcome, such as lack of appropriate OERs) and local barriers (i.e., barriers require administrative support from local school districts to resolve, such as lack of professional development). In particular, those teachers perceived these barriers as more challenging than personal barriers in using OER (Kimmons, 2016). In addition, teachers' use of OER is vulnerable to the influence of sociocultural and economic factors (Jimes et al., 2013; Tang & Bao, 2020). Teachers from relatively underdeveloped areas cannot sufficiently consume and/or produce OER due to limited education budgets for necessary infrastructure and constraints in the local educational system (Ngimwa & Wilson, 2012). To help teachers overcome these barriers, understanding what leads to the barriers and how the barriers influence their use of OER becomes critical.

This study aimed to conduct a person-centered analysis of K-12 teachers' barriers in implementing OER. Studies about K-12 teachers' barriers in using OER have mainly followed a descriptive approach using interviews or surveys that focused on what the barriers were (e.g., de los Arcos et al., 2016; Kimmons, 2016; Tang, 2020). However, evidence about the individual difference in how teachers' barriers influence their use of OER remains unknown. A person-centered approach considers "the relationships among constructs at the level of the individual" (Hayenga & Corpus, 2010, p. 372) and provides insights on offering tailored support for specific groups of individuals to satisfy their needs (Tang, 2018, 2021b). Thus, with this research, we hoped to advance the descriptive understanding of teachers' barriers in implementing OER by identifying teachers' profiles and further analyzing how various profile-specific attributes impact student learning. Such a person-centered understanding allows researchers and teacher educators to tap into profile-specific patterns and provide tailored support for teachers (Roeser et al., 1998).

Literature review

OER in K-12 education

The use of OER in K-12 settings has received increasing attention. OER provide teachers with free access to openly licensed educational resources so that they can adapt those resources to fulfill their own purposes (Read et al., 2020; Tang, 2021a; Wiley & Hilton,

2018). Specifically, teachers can reproduce and own a copy of OER (retain), use OER to suit their purpose (reuse), adapt and modify OER (revise), merge two or more existing OER tailored to their personal needs (remix), and disseminate OER for their own instructional purposes (redistribute) at no cost (Hilton, 2016; Y. J. Lin & Tang, 2017).

The evidence on how OER can be a cost-effective alternative to traditional textbooks in K-12 classrooms has been well documented. First, research has indicated that using OER can decrease educational costs for K-12 students. Wiley et al. (2012) found that USA public-school teachers using open textbooks in secondary science classrooms could help students save up to a half of the costs of adopting traditional textbooks. In South Africa, the Siyavula ("we are opening" in Nguni) initiative was launched to produce free open textbooks for high school science and math classrooms to offset the shortfall in textbooks (Jimes et al., 2013, p. 1). Second, research has indicated that using OER in various subjects caused no harm to K-12 students' academic achievement. De los Arcos et al. (2016) surveyed educators worldwide using OER in their lessons, and a majority of K-12 educators perceived that the use of OER increased or had not changed student test scores. Hilton et al. (2019) found that elementary students using open textbooks in mathematics classes did not have decreased performance in standardized tests. Robinson et al. (2014) indicated that secondary students using open science textbooks at a suburban public school even earned a slightly higher score on standardized tests than those using traditional textbooks.

Beyond cost-effectiveness, OER also provide teachers with openness and flexibility so that they can address students' individual needs (Kimmons, 2016). For instance, Park and Mcleod (2018) personalized high school mathematics instruction using OER to help students with learning disabilities learn effectively and become motivated to learn mathematics. Another advantage of OER over traditional textbooks is to allow teachers to use timely resources in OER repositories to tailor learning to students' emerging needs (Kimmons, 2015). Especially when course standards change, traditional textbooks usually cannot address the changes immediately as textbook adoption is usually not determined by teachers (Adebayo, 2018; Kimmons, 2015). In contrast, teachers might resort to OER and find supplementary content to adjust the instruction into alignment with the new standard. Therefore, K-12 education calls for adoption of OER in order to promote educational equity and personalized instruction (Tang et al., in press, 2020; Van Allen & Katz, 2019).

K-12 teachers' barriers in technology integration

The role of technology in current K-12 education is critical. A meta-analysis of technology integration studies over the past 28 years reported technology significantly affected student learning in various domains (Delgado et al., 2015). However, the effectiveness of technology integration is influenced by various barriers (Ertmer, 1999; Hew & Brush, 2007; Kopcha, 2012).

Barriers are defined as factors that make it challenging for teachers to integrate technology successfully in K-12 classrooms (Ertmer, 1999; Makki et al., 2018). Ertmer (1999) assigned teachers' barriers to technology integration to two categories—first-order (e.g., external) and second-order (e.g., internal) barriers. First-order barriers are those resulting from external causes and impacting technology-enhanced teaching practices, such as a lack of resources, constraints of institutional policy and/or challenges in

aligning with standardized test requirements and subject culture (Ertmer, 1999; Hew & Brush, 2007). Evidence regarding various external obstacles that impede teachers' technology integration across different countries has been documented. For example, Goktas et al. (2013) specified a lack of access to resources such as technology, technical support and professional development opportunities as the main barriers for Turkish elementary teachers' technology integration. Lim and Pannen (2012) noted the lack of support in funding and training opportunities constrained Indonesian teachers' technology integration efforts. Contextual factors such as school-level technological access also predicted teachers' technology integration in the USA in that a lack of school-level access reduced teachers' intention to use technology in teaching (Inan & Lowther 2010).

As technology has become increasingly available in current teaching practices, teachers have been less restricted by first-order barriers; meanwhile, second-order barriers have become the gatekeeper of teachers' technology integration (Ertmer et al., 2012; Makki et al., 2018). Second-order barriers are those internal obstacles that hinder teachers' technology integration such as teachers' inadequate knowledge and skills and their attitudes and beliefs (Ertmer, 1999; Hew & Brush, 2007). Evidence indicates teachers' second-order barriers are critical obstacles for teachers' technology integration (Inan & Lowther, 2010; Jones et al., 2017; Li et al., 2016; Tondeur et al., 2017). For example, teachers' beliefs and self-efficacy about technology integration can thwart their intention to adopt technology in their classrooms (Jones et al., 2017; Li et al., 2016). Additionally, teachers' fear of using technology and their lack of pedagogical knowledge to integrate technology decrease their readiness for technology integration (Inan & Lowther, 2010; Tondeur et al., 2017).

Therefore, successful technology integration in classrooms requires effective strategies to help teachers overcome barriers. Hew and Brush (2007) recommended establishing a shared school-wide vision on technology integration to overcome institutional barriers, but teachers also need effective professional development to overcome second-order barriers. Research has suggested numerous strategies to deliver effective professional development for teachers to improve their beliefs, attitude, and expertise about technology integration (Ertmer et al., 2012; Inan & Lowther, 2010; Kopcha, 2012). For example, Ertmer et al. (2012) recommended that professional development needs to focus on improving teachers' skills and knowledge associated with technology integration so as to strengthen teachers' confidence and erase their fear of technology use in classrooms. Kopcha (2012) implemented situated professional development activities (e.g., mentoring, teacher-led community of practice) to support teachers' technology integration. Furthermore, vicarious experiences such as presenting teachers with examples of best practices for technology usage in classrooms can help facilitate their beliefs about technology integration (Inan & Lowther, 2010).

K-12 teachers' barriers in using OER

As previously stated, teachers encounter barriers when integrating OER in K-12 instruction (Kimmons, 2016; Tang, 2020, 2021a). Tang (2020) categorized K-12 teachers' barriers in using OER as first-order (e.g., a lack of supportive climate and sufficient time and/or support) and second-order barriers (e.g., lack of proficiency in searching OER and pedagogical knowledge about integrating OER), referring to seminal works by Ertmer (1999)

and Hew and Brush (2007). Beyond the dichotomy of barriers, Kimmons (2016) discussed three levels of teachers' perceived barriers—macro, local, and personal barriers—with a focus on who can solve the barriers of integrating OER in K-12 classrooms. Specifically, macro barriers are teachers' barriers that exceed the reach of local school districts but require "outside help from states, publishers, and other entities to overcome (e.g., through legislation or market forces)" (p. 22), such as a lack of legislative support and a lack of appropriate OER (Kimmons, 2016). Local barriers are those that require support from schools and districts to overcome, including a lack of time, technology infrastructures, opportunities for professional development, and community acknowledgment (Kimmons, 2016). Personal barriers, similar to second-order barriers (Ertmer, 1999), include those that can be solved by teachers themselves, such as teachers' beliefs, values, and expertise about using OER (Kimmons, 2016). All of these barriers challenge K-12 teachers' integration of OER, but Kimmons (2016) indicated that macro and local barriers were more challenging for teachers.

Teachers need to overcome barriers when implementing OER in instruction, but strategies for teachers to overcome these barriers are relatively absent in the literature. In addition, teachers' struggle with implementing OER in K-12 classrooms can impact the effectiveness of OER in teaching and learning (Kimmons, 2016). This further renders the need to support teachers with different profiles. To fill the gap in the existing understanding of K-12 teachers' barriers in implementing OER, this research aimed to investigate the following research questions:

(1) What are teachers' profiles in regard to their barriers in implementing OER?
(2) How does teachers' perception of OER differ by their profiles?

Methodology

Dataset

The dataset used in this research was retrieved from a secondary dataset published by the OER Research Hub (https://oerresearchhub.org/) at the Open University, United Kingdom. It was released with creative common licenses (CC-BY) on figshare (http://figshare.com/articles/OERRH_Survey_ Data_2013_2014/1317313), allowing researchers to adapt and distribute it for personalized purposes (Farrow et al., 2015). The dataset provides survey responses collected by the OER Research Hub to assess respondents' perception of how OER influence teaching and learning (Farrow et al., 2015). The survey data was collected between 2013 and 2015. Ethical approval from the Student Research Project Panel at The Open University, United Kingdom, was obtained before the survey was made available (Farrow et al., 2015). The survey respondents for this dataset included educators from different sectors (e.g., higher education instructors, K-12 teachers), librarians, and also learners using OER for their formal education and/or informal learning opportunities. These respondents were invited via email and social media to answer different survey questions based on their identity. Survey responses from around 6,390 people in 180 different countries were recorded in the dataset (Farrow et al., 2015).

Participants

For the research, we selected participants who met two criteria:

- K-12 teachers. A total of 675 K-12 teachers were identified based on their responses to the questions "What is your role?" and "Within which educational context(s) do you work?".
- Only those K-12 teachers who responded to the question "Which challenges, if any, do you most often face in using OER" were retained as participants (N = 367).

Of the 367 participants, 125 were female, and 130 were male. The other 111 participants did not specify their gender. Participants came from 72 countries. Of the 367 participants, 242 recorded their first language, of whom 82 were native English-speakers. Of the 330 who indicated their teaching experience, over half (n = 202) had taught for at least three years in K-12 schools.

Variables

Teachers' barriers in using OER

This variable described whether teachers had met any of the barriers, based on their responses to the survey question, "Which challenges, if any, do you most often face in using OER?". The question consisted of 17 items. One was a fill-in item for the participants to write down other barriers that they had experienced (fill-in responses were not provided in the dataset). The participants responded "no" to an item if they had not encountered that barrier; otherwise, they answered "yes" if they had. To interpret the barriers, we coded the items according to Kimmons' (2016) categories of teachers' barriers in using OER. Another item—"not having connections with OER-using peers"—was removed because it did not address any dimension of the barriers (i.e., macro, local, and personal barriers) discussed in our study (Kimmons, 2016). Finally, we recorded five items for each level of barriers (see Table 1).

Distal outcomes

To understand how various barriers influence teachers' perceived effectiveness of OER in teaching and learning, we investigated how their profiles impacted their self-reported outcome of using OER. Distal outcomes for this research consisted of teachers' responses to eight items (see Table 2) about their perceived effectiveness of OER. In particular, two distal outcomes are dichotomous items included in the question "In which of these ways, if any, have you used OER?". Participants' responses to these questions recorded their usage patterns of OER and were noted as categorical variables, with 1 representing "yes" and 0 denoting "no". Five items from the question, "To what extent do you agree with the following statements about the impact of OER use on students?" were also selected. These five items used a 5-point Likert scale to inquire about teachers' perceptions about how OER impact student learning: *strongly disagree* (1), *disagree* (2), *neither disagree nor agree* (3), *agree* (4), and *strongly agree* (5). One item was chosen from the question, "As a result of using OER, are you more or less likely to do any of the following?" to evaluate teachers' intention of continuing to use OER for their teaching. This item used a 3-point Likert scale: *less likely* (1), *no change* (2), *more likely* (3). A response of "do not know" was discarded for this analysis.

Table 1. Question about teachers' barriers in using OER.

Categories	Subcategories	Items
Macro barriers	Lack of appropriate OER	M1. Finding suitable resources in my subject area
		M2. Finding resources of sufficiently high quality
		M3. Finding resources that are up-to-date
		M4. Finding resources that are relevant to my local context
		M5. Resources not being aligned with professional standards
Local barriers	Lack of community buy-in	L1. Getting work colleagues/managers to accept the use of OER
	Lack of time	L2. Not having enough time to look for suitable resources
		L3. Not having enough time/opportunities to experiment
	Lack of institutional support	L4. Lacking institutional support for my use of OER
	Lack of professional development	L5. Missing/needing the support of a tutor or teacher to help me
Personal barriers	Lack of technology skills	P1. Overcoming technology problems when downloading resources
	Lack of knowledge about technology	P2. Knowing where to find resources
		P3. Not knowing whether I have permission to use, change or modify resources
	Lack of skills and/or knowledge about integrating technology	P4. Not being skilled enough to edit resources to suit my own context
		P5. Not knowing how to use the resources in the classroom

Table 2. Items for the distal outcomes and their question types.

Distal outcomes	Question types
I have adapted OER to fit my needs	Yes/no
I have created resources myself and published them on an open license	Yes/no
I collaborate more with colleagues	Likert scale (1–5)
Increases learners' satisfaction with the learning experience	Likert scale (1–5)
Leads to improved student grades	Likert scale (1–5)
Allows me to better accommodate diverse learners' needs	Likert scale (1–5)
Increases learners' engagement with lesson content	Likert scale (1–5)
Make use of materials for teaching	Likert scale (1–3)

Data analysis

We conducted a latent class analysis (LCA) using Mplus 8.0 (Muthén & Muthén, 2017) to determine empirically the number of latent classes of teachers' barriers of using OER. LCA includes a group of discrete latent variable models for multivariate categorical data (Collins & Lanza, 2009). In this study, each discrete value for the latent variable represents a latent class characterized by a pattern of conditional probabilities of teachers' barriers of using OER.

Specifically, a three-step approach of the LCA analysis with the distal outcome (Asparouhov & Muthén, 2014) was used in this study. The first step determining the optimal number of latent classes. We examined two types of latent class models: (1) latent class models with the class number ranging from two to five; and (2) the restricted latent class model with eight fixed latent classes. For restricted models, the eight latent classes were decided upon in line with Kimmons' (2016) framework of teachers' barriers in using OER. Kimmons (2016) described three levels of relevant

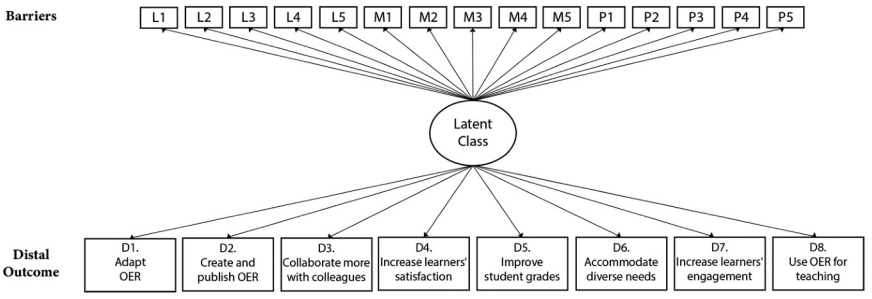

Figure 1. LCA with distal outcome. L1–L5 represent the items that measure the local barrier. M1–M5 represent the items that measure the macro barrier. P1–P5 represent the items that measure the personal barrier. D1–D8 represent the distal outcome items.

barriers (e.g., macro, local, and personal barriers); therefore, the maximum number of possible classes was eight. To determine the best fitting model, we computed loglikelihood value, Akaike information criterion (AIC; Akaike, 1974) Bayesian information criterion (BIC; Schwarz,1978), sample-adjusted BIC (SABIC; Sclove, 1987). Lower values of these indices indicate a better fitted model. The second step was assigning participants into the latent classes determined in the first step and then compute the measurement error of the classification. The third step was estimating the desired auxiliary model to analyze distal outcomes by incorporating the classification and fixing the measurement errors obtained from the second step. The overall model is presented in Figure 1.

Results

Model selection

Table 3 presents the result of the three model selection indices for the five latent class models. The 3-class model had the lowest BIC values, and the 5-class model recorded the smallest AIC and SABIC values. Since BIC is a preferable index of choosing the number of latent classes (T. H. Lin & Dayton, 1997), we adopted the 3-class model as the best fitting model. It is noteworthy that the restricted latent class model with eight classes was not the best fit model although it was developed based upon the theoretical framework of this study (Kimmons, 2016).

Table 3. Model selection indices for nine latent class models.

Class number	AIC	BIC	SABIC
2	5560.017	5681.084	5582.732
3	5496.471	5680.023	5530.910
4	5479.440	5725.478	5525.603
5	5463.501	5772.025	5521.388
8 (restricted)	5543.642	5688.141	5570.754

Note. 8 (restricted) represents the restricted latent class model with eight predefined latent classes.

LCA results

Based on the model selection results, participants were classified into three latent classes (see Figure 2). Note that we coded 1 for an item when a teacher encountered the barrier described in that item; therefore, a class with a lower mean score for any of the three categories of barriers (i.e., macro, local, and personal barriers) indicated teachers were more likely to possess the corresponding barrier.

The first class was the savvy class, consisting of 197 participants (53.7%). This class had the lowest mean of the scores (approximately 0.2) for all the categories of barriers in using OER. This result indicates that this class of teachers were likely not to have any of the three barriers when using OER.

The second class was the struggling class, consisting of 36 participants (9.8%). The mean scores for this class to meet any barriers were all close to 0.8, suggesting that teachers in this class were more likely to have all the types of barriers when using OER. In particular, compared to the other two classes, this class recorded a much higher score (over 0.8) in the probability to bump into personal barriers. In addition, this class also had the highest likelihood of personal barriers among the three types of OER.

The third class was the resource-constraint class, consisting of 134 participants (36.5%). The mean score of the likelihood for this class to run into macro barriers was nearly 0.7, but the mean scores for the other two types of barriers were only about 0.3. In particular, the likelihood for this class to meet each category of the barriers was higher than that of the struggling class but lower than that of the savvy class. This result suggests that teachers in this class were more likely to be challenged by a lack of resources when implementing OER in the class.

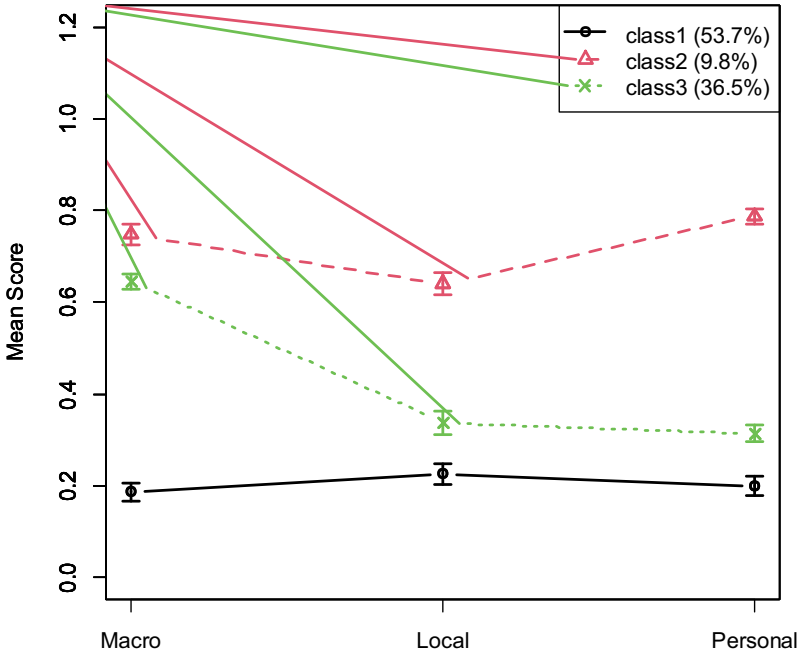

Figure 2. Mean scores of each barrier category for different latent classes.

Figure 3 demonstrates a sample diagnosis report sheet that can be provided to an individual with ID 217 who took the survey. The top part of the report reviews the respondent's answer to each item grouped by barrier type. The sum score for each barrier type is in the next column. The last column is the barrier type estimated from the latent class analysis. The check represents the respondent does not possess the barrier, and the flag represents the opposite. Respondent 217 did not have macro barriers but did have local and personal barriers. Moving on to the lower panel, the left figure entails further details about the comparison of the respondent's scores for each barrier and those for the three classes. The blue line in the figure, representing the respondent's scores, shows a consistent pattern for the mean scores of the three barriers proximate to that of respondents from Class 3 (resource-constraint) yet apart from Class 1 (savvy) and Class 2 (struggling). The figure on the right side of the lower panel provides further evidence about the certainty of this classification: the probability of classifying Respondent 217 to Class 3 equals .945 but only .055 for Class 1. This result confirms that we classified Respondent 217 to Class 3. On the bottom right of the report card, the respondent can be offered a brief summary of the survey responses, classification results, and the corresponding evidence to support the classification.

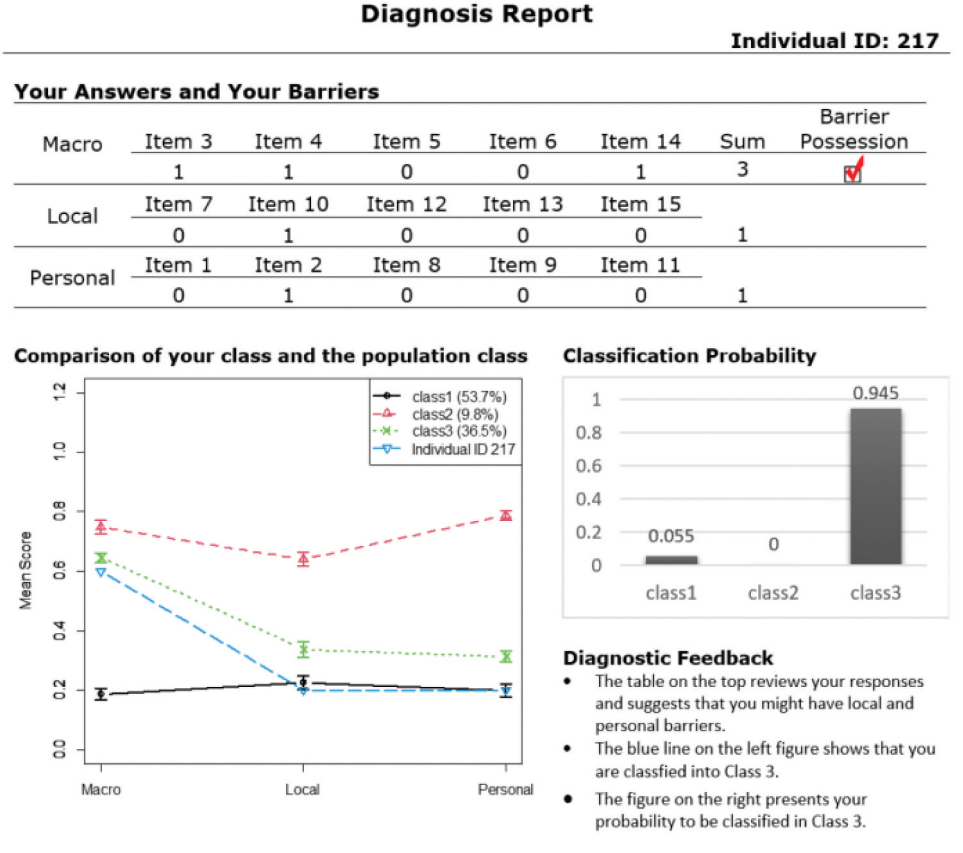

Figure 3. Sample person-centered diagnosis report for Respondent 217.

Table 4. Estimated mean for each distal outcome items across the three classes.

Item stem	Class 1: No barriers	Class 2: All barriers	Class 3: Macro barriers
D1. I have adapted OER to fit my needs	0.813	0.823	0.890
D2. I have created resources myself and published them on an open license	0.102	0.131	0.112
D3. I collaborate more with colleagues	3.404	3.055	3.750
D4. Increases learners' satisfaction with the learning experience	3.661	3.072	4.342
D5. Leads to improved student grades	3.345	2.917	4.130
D6. Allows me to better accommodate diverse learners' needs	3.742	3.244	4.478
D7. Increases learners' engagement with lesson content	3.605	3.156	4.416
D8. Make use of [repository] materials for teaching	1.956	3.000	3.000

Distal outcome interpretation

Table 4 shows the result of the three-step approach that was used to estimate distal outcomes.

Two of the eight distal outcomes were dichotomous items, in which 0 denoted that teachers did not use OER in the manner as described, but 1 indicated they did. For the item, "I have adapted OER to fit my needs", the high mean scores across the three classes (over 0.8) suggests that most teachers adapted OER to fit their needs rather than grabbing OER off the shelf. In particular, the resource-constraint class had the highest possibility of adapting OER. For another dichotomous item "I have created resources myself and published them on an open license", only around 10% of teachers responded that they had done so. Despite the struggling class recording the highest possibilities, creating and then publishing their own resources as OER was not common for teachers yet.

The remaining six distal outcomes were Likert-scale items. Five items looked into teachers' perception of the impact of OER on teaching and learning. Teachers in the resource-constraint class had the highest estimated means for each of the items, showing that they were more likely to collaborate with colleagues after using OER and also believe using OER increased learners' satisfaction, improved student grades, better accommodated learners' needs, and also increased learners' engagement with the lesson content. In contrast, the struggling class had the lowest mean estimates for the aforementioned items and thus were less likely to collaborate with colleagues after using OER and did not perceive that OER improved student learning. The other Likert-scale item applied a 3-point likely scale to inquire whether teachers were more likely to use OER repository materials for future teaching, with 1 representing *less likely* and 3 denoting *most likely*. Teachers from the savvy class were more likely to have no change ($M = 1.96$) in this item, but the struggling and the resource-constraint classes were both more likely ($M = 3.00$) to integrate OER repository materials in the class.

Discussion

This study, as an initial effort, investigated teachers' barriers in using OER from a person-centered perspective. Teachers' barriers in using OER differ among individuals and contexts; therefore, supporting each teacher to meet their individual needs for OER involves an understanding of teachers' unique experiences. This person-centered analysis adds to

the current understanding of barriers that hinder teachers' use of OER and provides granular insights into teachers' needs to overcome those barriers. Specifically, the study revealed three classes of teacher profiles based on their self-reported barriers in using OER: the savvy, struggling, and resource-constraint classes. The three-step model of the LCA analysis with distal outcome was performed to identify nuanced difference among those three classes and further suggest implications of supporting each group of teachers' use of OER.

The savvy class consisted of those who were highly likely to report no barriers in using OER, amounting to more than a half of all the teachers in the sample. However, this result did not assume that those teachers effectively use OER in their teaching without any hurdles. For example, adaptation was considered one of the most efficient ways of using OER (Kimmons, 2015; Van Allen & Katz, 2019), but it is surprising that this class had the lowest likelihood of adapting OER. Additional evidence is needed to determine whether teachers' low adaptation of OER led to their low perception of the barriers in using OER. This result also suggests that professional support for this class of teachers may gear more toward improving their sense and skillset of adapting OER tailored to individual needs instead of simply downloading and reusing existing OER. In addition, this class of teachers recorded no changes in their intentions to integrate OER repositories in their future classes. Their perception of OER's impact on teaching and learning falls between *neither agree nor disagree* (3) and *agree* (4). We speculate that those results may also be due to a lack of experience with adapting OER. Merely retaining or reusing OER without any adaptation may not allow teachers to experience the openness and flexibility inherent to OER (Kimmons, 2016; Park & Mcleod, 2018), as they are likely to integrate common online resources in their lessons.

Teachers in the resource-constraint class were those with a much higher likelihood of encountering macro barriers—especially a lack of appropriate OER—than other types of barriers, but this class of teachers were the most likely to adapt OER. We speculate that this class of teachers made revisions to or remixed OER to satisfy instructional needs as they might have had difficulties in finding OER that fit their needs. Future research may investigate whether any causal relationship exists between teachers' high tendency to adapt OER and their high likelihood of facing macro barriers, such as a lack of appropriate resources. In addition, the resource-constraint class reported the highest appraisal of the impact of OER on teaching and learning and was more likely to integrate OER in future teaching practices. This result seems promising; however, to support this class of teachers, external aids beyond the school district should be provided from governments, educational authorities, and publishers for the teachers to overcome the macro barriers in using OER (Kimmons, 2016; Tang, 2020).

The struggling class grouped together the teachers with a high likelihood of bumping into all types of barriers, but this class involved only a small percentage of the teachers in this study. It is no surprise that the struggling class had the lowest perception of the impact of OER on teaching and learning as most of the responses were approximately *neither disagree nor agree* (3). It is noteworthy that teachers in this class had a much higher percentage of encountering personal and school-level barriers, but they reported they were more likely to integrate OER in future teaching practices. Supporting this class of teachers is critical to further the adoption of OER in K-12 settings, but it needs to involve various stakeholders (e.g., government, educational authority, school district, and

teachers). We speculate that some nationwide initiatives with a focus on open education, such as the #GoOpen initiative sponsored by the United States Department of Education (n.d.), can help more local educational authorities and school districts get onboard with implementing OER in K-12 settings (Tang et al., 2020). To resolve local school-level barriers, involving school districts is highly necessary to advance the effort to promote OER in K-12 settings (Kimmons, 2016). For this class of teachers' personal barriers, professional development opportunities oriented to using, adapting, creating, and publishing OER may be needed (Ertmer et al., 2012; Kimmons, 2016; Kopcha, 2012).

In addition, the findings of this study reveal a gap between teachers' increasing need for appropriate OER and teachers' low intention of creating and sharing OER. The macro barriers (Kimmons, 2016), specifically the lack of appropriate OER, remain a main challenge for about half of the teachers in this study. Teachers were still challenged by the lack of OER which are relevant to some subject areas, of high quality and timeliness, and aligned with local course standard and contexts. Research suggests that a viable option to overcome the shortage of appropriate OER for K-12 instruction is to involve teachers in creating customized resources (e.g., lesson plans, instructional materials) and then publishing them as OER (Blomgren, 2018; Tang, 2020; Van Allen & Katz, 2019). However, this study suggests that only about 10% of the teachers created and shared their resources with open licenses. This gap reinforces the need to encourage K-12 teachers to participate in creating and sharing OERs. Specifically, implementing open educational practices (OEP) in teacher professional development programs may help encourage teachers to produce and publish their own OER (Tang, 2020; Tang et al., 2020). OEP includes a series of practices of finding, creating, adapting, integrating and then redistributing OER (Wiley & Hilton, 2018). By providing teachers with a contextualized experience, OEP hold the potential to empower teachers with the capacity of efficiently creating and publishing OER and addressing the shortage of appropriate OER for K-12 settings.

This study was constrained by several limitations. First, we coded participants' responses into several barriers in line with Kimmons' (2016) framework, but subjectivity in the coding procedures could still be detrimental to the findings. Second, we used a listwise deletion method to manage the missing data and removed the observations with at least one missing response to the items. Third, the study focused only on self-reported data based on an existing open dataset; and this sole source of data might also decrease the trustworthiness of the findings. For example, although all the participants had used OER previously, we did not investigate whether they reached a common understanding about "adapt" in the item "I have adapted OER to fit my needs". On the other hand, the dataset was collected several years ago, and some data may not accurately reflect the current landscape of OER use in K-12 education. Fourth, we used the most common method, the three-step approach, to analyze the distal outcomes. It would be beneficial to researchers and practitioners if other possible approaches (e.g., one-step approach) are conducted as well. For future research, we recommend conducting an empirical study collecting multiple modalities of data describing teachers' barriers in using OER. On the other hand, we suggest analyzing the causality, if any, between teachers' barriers and their relevant teaching behaviors (e.g., adapting OER, continuing to integrate OER). A more granular understanding of the causal relationships between

those variables may help scholars and educators devise strategies better tailored to supporting teachers in a specific class.

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Disclosure statement

No potential conflict of interest was declared by the authors.

Data availability statement

The data that support the findings of this study are openly available on figshare at https://doi.org/10.6084/m9.figshare.1317313.v1, reference number 1317313.

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