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ENGAGING STUDENTS WITH TECHNOLOGY: HOW AN INNOVATIVE SCHOOL CLIMATE AND TEACHER INNOVATIVE BEHAVIOR ENHANCE TECHNOLOGY-SUPPORTED TEACHING

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A B S T R A C T

Technology-enhanced teaching has the potential to significantly improve student learning outcomes. Nevertheless, the question of what factors predict teacher use of technology in cognitive demanding ways is still open. Drawing on the theory of interactive, constructive, active, and passive (ICAP) learning, this study aimed to examine the relationships between a school's innovative climate, teachers' innovative behavior, and different modes of technology use in the classroom. The participants were 458 teachers from Serbian schools. Full structural equation modeling revealed that teachers' innovative behavior is positively related to different types of technology integration in learning activities. Furthermore, a school's innovative climate was related to passive, active, constructive, and interactive technology use via the innovative behavior of teachers. On the other hand, an innovative school climate was not directly related to the dimensions of technology use in teaching and learning activities. The obtained findings have implications for both practitioners and professional development providers.

Key words:

technology use, ICAP, teacher innovative behavior, innovative climate.

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■ INTRODUCTION

How to get students highly engaged during instruction is a critical practical and scientific issue. Some of the predictors of different levels of students' cognitive engagement with technology that have been found are principal leadership (Schmitz et al., 2023), a school's innovative climate (Ninković et al., 2023), and digital skills of teachers (Sailer et al., 2021). However, despite the valuable insights gained so far, the mediated paths linking the characteristics of teachers and the school environment to instruction with digital technologies have rarely been examined. Therefore, the focus of this study is the relationship between a school's innovative climate, the innovative behavior of teachers, and learning activities that involve digital technologies. In addition, the second contribution of this paper is of a methodological nature. Based on the prevailing opinion of experts (McNeish & Wolf, 2020), in this study we applied full structural equation modeling for a more accurate assessment of the relationships between the examined variables.

Interactive, Constructive, Active and Passive Technology Integration

ICAP is an acronym for four modes of cognitive engagement of students with instructional materials, which are called interactive, constructive, active, and passive (Chi et al., 2018; Chi & Wylie, 2014). In passive learning activities, students are content-oriented and absorb information from instructional materials (e.g., students listen to a lecture or watch a video) (Antonietti et al., 2023). Active learning occurs when students have the possibility to manipulate the learning material (e.g., pausing a video or underlining text). In this way, students activate previous knowledge and integrate new information into existing knowledge structures (Chi, 2021; Chi & Wylie, 2014). When students learn constructively, they individually create new knowledge based on deriving information that is not explicitly presented in the teaching content (Chi, 2021). An example of an activity at this level is taking notes using your own vocabulary and giving your own examples. Interactive learning occurs when students interact and collaborate with others to build knowledge from their own prior knowledge and from information provided by their partners (e.g., exchanging ideas, discussing their arguments, constructing a common point of view). These interactive exchanges enhance knowledge for everyone involved and help develop social skills (Antonietti et al., 2023). It is important to bear in mind that the ICAP theory assumes that these four types of student cognitive engagement are hierarchically organized so that interactive activities result in the highest level of learning (Chi et al., 2018).

The ICAP theory has clear practical implications as teachers can use it to select, modify or design tasks for students. Also, with this framework, student outcomes can be coded and evaluated (Chi & Wylie, 2014). In the context of integrating technology into teaching, the ICAP theory emphasizes the importance of quality application of technology in order to cognitively activate students (Antonietti et al., 2023; Consoli et al., 2023; Fütterer et al., 2023). In other words, teaching and learning activities supported by technology can be differentiated based on the level of cognitive engagement of students (Antonietti et al., 2023). Low-quality technology integration refers to how often teachers use technology primarily for presentation or lecturing. On the other hand, digital technologies are particularly suitable for enhancing learning activities at the upper end of the ICAP spectrum (Sailer et al., 2024).

The ICAP framework has been increasingly supported by empirical research on the educational use of technology (Wekerle et al., 2022; Zhao et al., 2024). Based on a systematic review of meta-analyses, Sailer et al. (2024) came to the conclusion that engaging students in active forms of learning, especially constructive and interactive learning activities with the help of digital technologies, can improve learning outcomes in higher education. Strengths of digital technologies concern the provision of timely feedback and cognitive scaffolding (Sailer et al., 2024). Given the findings that have been accumulated so far, it is important to continue to examine the antecedents of the use of digital technologies for the cognitive engagement of students.

The Relationship between Teacher Innovative Behavior and Technology Integration

Innovative behavior is widely recognized as one of the crucial professional competencies of teachers (Anderson et al., 2022). Although this concept is not consistently defined in the scientific literature, the difference between innovative behavior and the creativity of teachers is usually emphasized (Liu et al., 2024). Creativity means the generation of novel ideas that do not necessarily have to be put into practice. On the other hand, innovative behavior, in addition to creative thinking, includes public advocacy and practical implementation of creative ideas (De Jong & Den Hartog, 2010; Liu et al., 2024). In addition, it should be borne in mind that the professional behavior of teachers can be marked as innovative only if it results in new solutions to existing problems (De Jong & Den Hartog, 2010; Liu et al., 2024).

The current study is based on the five-dimensional model of innovative behavior proposed by De Jong and Den Hartog (2010). The first component of the construct labeled as exploration of ideas includes the review of possibilities for improving practice. Generation of ideas, the second component of the construct, is focused on searching for new approaches to performing tasks or solving existing

problems. Championing of ideas refers to influencing the willingness of collective members to support the introduction of innovations. Finally, idea implementation concerns the practical application of creative solutions. This conception of innovative behavior is universal and relevant to various professions, including the role of teachers.

Existing literature indicates that teacher innovation is positively related to effective teaching practices. For example, Ucus and Acar (2018) reported that teacher innovation, via creative behavior, has a positive effect on constructivist teaching. This means that teachers who are innovative tend to cognitively activate students, instead of directly imparting knowledge to them. It has been shown that a teacher's sense of accountability is significantly related to innovative thinking, which has a positive effect on responsible teaching (Orakcı et al., 2020). Furthermore, empirical evidence suggests that the innovative behavior of teachers positively predicts motivational outcomes of students. For example, using data collected from teachers and students in India, Maun et al. (2023) found that teachers' innovative practice measured at the beginning of the school year positively predicts student internal goal orientation at the end of the academic year.

The current empirical evidence compellingly indicates that teacher innovation can be in the function of the application of technology in teaching. High-quality teaching that includes technology can be seen as a form of innovative teacher behavior (Thurlings et al., 2015). From this perspective, technological tools allow teachers to effectively introduce innovations in their work. For example, starting from the Technology Acceptance Model, Mazman Akar (2019) found that teachers classified as highly innovative achieve higher scores on measures of perceived usefulness and ease of technology use. Vidergor (2023) documented that teacher innovative behavior is positively related to successful distance teaching practices. Furthermore, teachers' sense of responsibility for their own behavior and results had a mediating role in the relationship between these variables. Despite the fact that previous research has accumulated valuable knowledge, researchers have not yet addressed the relationship between teacher innovative behavior and different types of technology use in teaching and learning.

The Mediating Role of Teacher Innovative Behavior in the Relationship Between Innovative School Climate and Technology Integration

Innovative climate is a complex phenomenon that has attracted the attention of researchers for decades. This construct can be defined as 'employees' perceptions of the extent to which the team or organizational environment is conducive to innovation and the innovative behavior of employees' (Newman et al., 2020: 77). Innovative climate can be operationalized as a personal perception or as a shared perception of

team or organization members (Blömeke et al., 2021; Newman et al., 2020). In the current study, school innovative climate was measured as the personal perception that teachers have about the characteristics of the school environment in which they work.

Scholars (Blömeke et al., 2021) have shown that a school's innovative climate is a positive predictor of technology-assisted instruction and students' cognitive engagement. Chou et al. (2019) reported that an innovative school climate strongly predicts innovative use of information and communication technology in teaching in a Taiwanese context. In a sample of teachers from five Asian countries, Fang et al. (2024) found that team innovativeness was significantly related to the degree of teacher encouragement of students to use digital technologies. However, research on the effects of an innovative school climate on qualitatively different ways of integrating technology into teaching activities is scarce. In one of the few multilevel studies, Ninković et al. (2023) found that teachers' perceptions of innovative climate within the school positively predicted all four types of technology use, differentiated according to the ICAP theory. On the other hand, the innovative climate at the school level did not significantly predict the average application of technology in different types of learning activities.

The theory of planned behavior (Ajzen, 2020) represents a relevant frame of reference for interpreting the relationship between the school's organizational environment and the individual behavior of teachers. According to this theoretical approach, the factors that determine an individual's behavior are personal attitudes, subjective norms, and perceived behavioral control. Particularly relevant for the current study is the role of the subjective norm, which is the belief that significant others approve of and perform certain behaviors themselves (Ajzen, 2020). This means that when teachers work in a school where the school principal and colleagues approve of introducing changes to existing practices, they are more likely to pursue innovative behavior themselves. This theoretical expectation is supported by previous empirical research (see Liu et al., 2024). For example, Blömeke et al. (2021) using data from multiple countries found that perceptions of school innovativeness are positively related to teachers' innovative practices.

Research Questions

Drawing on relevant theory and empirical evidence, this study is based on a hypothetical model that implies the following research questions:

Research question 1. How is teacher innovative behavior related to different types of technology use in teaching and learning?

Hypothesis 1. Based on previous research on teaching in face-to-face (Ucus & Acar, 2018) and remote settings (Vidergor, 2023), we expect that the innovative behavior of teachers is positively related to the implementation of technology in different types of learning activities.

Research question 2. Does teacher innovative behavior mediate the relationship between school innovative climate and different dimensions of technology use in learning activities?

Hypothesis 2a. In accordance with existing literature (Chou et al., 2019; Ninković et al., 2023), it is assumed that teachers who perceive the school climate as more innovative tend to implement technology in teaching more often.

Hypothesis 2b. We assume that teachers' innovative behavior mediates the relationship between a school's innovative climate and different modes of technology use in teaching and learning.

■ METHODS

Samples and Procedure

A total of 458 teachers from 70 schools participated in the research. The average age of the teachers was 47.24 ($SD=9.44$) years. The participants' average length of work experience was 18.88 ($SD=10.00$) years, ranging from less than one year to 41 years of teaching experience. The majority of the sample was female (82%), while 18% were male. Teachers working at all levels of the school system in Serbia participated in the research, including 79 (17%) classroom teachers, 135 (29%) subject teachers from primary schools, 128 (28%) subject teachers from grammar schools, and 116 (25%) teachers from vocational high schools.

The researchers contacted the schools via email with a request to participate in the study. After obtaining consent from the school administration, the link to the online survey was forwarded to the teachers. All participants were informed about the purpose of the research, as well as the fact that participation was completely voluntary and anonymous. The teachers accessed the electronic questionnaire at a convenient time within a week of receiving the link.

Instruments

School innovative climate. This variable was assessed using an instrument created by Moolenaar et al. (2010). The scale contains six items (e.g. "Teachers are generally willing to try new ideas") that measure teachers' individual perceptions of the innovativeness of the school environment. The teachers provided their answers using a

five-point Likert scale. The fit of the one-factor model of this measure was excellent: $\chi^2(9)=20.109$, $p=.017$, CFI=.989, TLI=.982, RMSEA=.061 [90% CI=(.025, .096)], and SRMR=.019. The internal consistency of the scale was high ($\omega=0.885$).

Teacher innovative behavior. This construct was measured employing the scale developed by De Jong and Den Hartog (2010). The scale contains a total of ten items that assess four dimensions of innovative behavior: idea exploration, idea generation, idea championing, and idea implementation. An example of an item for the idea implementation dimension is “contribute to the implementation of new ideas”. In its original form, this instrument was intended for managers who evaluate the innovative behavior of employees. However, following earlier research (e.g., Vidergor, 2023), in this study the items were modified in such a way that they were intended for self-assessment of innovative behavior. The creators of the scale suggested that the innovative behavior of teachers can be treated as a second-order construct. In the present study, the hierarchical model of innovative behavior of teachers had acceptable fit indices: $\chi^2(31)=116.471$, $p<.001$, CFI=.964, TLI=.948, RMSEA=.089 [90% CI=(.072, .106)], and SRMR=.035. The reliability of the second-order measure was very high ($\omega=0.943$).

Technology integration. The ICAP technology scale created by Antonietti et al. (2023) was used to measure how frequently teachers use technology to implement different types of learning activities. The scale consists of 12 items that are divided into four dimensions: passive, active, constructive, and interactive learning activities supported by technology. When answering, teachers indicated how often they and their students use technology to accomplish the described activities. An example of an item for interactive learning activities that are considered most desirable is “so that they can discuss different points of view with others”. Responses ranged on a five-point Likert scale from “almost never” (0) to “almost every lesson” (4). The authors of the scale showed that a model with four first-order factors and a model with one higher-order factor fitted the data equally well. In the current study, we chose to use a model with first-order factors, in order to obtain a nuanced picture of the effects of predictors on the use of technology in teaching and learning. The fit of this model was acceptable: $\chi^2(48)=132.203$, $p<.001$, CFI=.975, TLI=.965, RMSEA=.075, [90% CI=(.059, .090)], and SRMR=.043. The internal consistency coefficients of the subscales were high ($\omega=0.818$ for passive use, $\omega=0.869$ for active use, $\omega=0.934$ for constructive use, $\omega=0.908$ for interactive use).

Data Analysis

The construct validity of the used measures was evaluated using confirmatory factor analysis (CFA). Hypotheses were tested using full structural equation modeling (full SEM). This analytical technique enables the testing of direct and mediated pathways between multiple variables. All variables were treated as latent constructs for more

reliable estimation of effects. Although teachers are clustered within schools, multi-level modeling was not applied in this study, since we did not focus on differentiating within-school and between-school effects of predictor variables. Nevertheless, in order to ensure precise statistical conclusions about the investigated effects, the obtained findings were verified by using cluster-robust standard errors (McNeish et al., 2017).

In this study, when evaluating measurement and structural models, several fit indices were used, such as comparative fit index (CFI), Tucker-Lewis index (TLI), root meansquare error of approximation (RMSEA), and standardized root mean square residual (SRMR). The traditionally proposed cutoff values of fit indices are as follows (Hu & Bentler, 1999): CFI and TLI values close to .95 indicate an acceptable fit of the model with the data, while RMSEA and SRMR values around .06 and .08 are interpreted as indicators of an acceptable fit. All indices were taken into account when interpreting the model fit, bearing in mind that the proposed cutoff values are not universally applicable (McNeish & Wolf, 2021). The estimation method was maximum likelihood with robust standard errors (MLR) in order to take into account the violation of the assumption of normal data distribution (Savalei & Rosseel, 2022). In accordance with the recommendations in contemporary methodological literature (Montoya, 2023), confidence intervals were created for indirect effects using the bootstrapping procedure with 10,000 resamples generated from the original data. A specific indirect effect of a variable is statistically significant if its confidence intervals do not include zero.

Analyses were conducted using the R Statistical language (version 4.2.2; R Core Team, 2022), using the packages *dplyr* (version 1.1.4; Wickham et al., 2023) for general data manipulation, *psych* (version 2.4.3; Revelle, 2024) for calculating correlations among variables, *semTools* (version 0.5.6; Jorgensen et al., 2022) for evaluating the reliability of the measures, *lavaan* (version 0.6.18; Rosseel, 2012) for structural equation modeling, *parameters* (version 0.21.7; Lüdtke et al., 2020) for obtaining and reporting model parameters, and *report* (version 0.5.8; Makowski et al., 2023) for properly formatting the results of the statistical analyses.

■ RESULTS

Preliminary Analysis

Table 1 shows descriptive statistics and correlations between the examined variables. Innovative school climate had relatively low positive correlations with dimensions of innovative behavior of teachers and integration of technology in teaching. On the other hand, correlations between teachers’ innovative behavior and types of technology integration were moderately positive.

Table 1. Descriptive statistics and correlations of the examined variables

Scale	1	2	3	4	5	6	7	8	9
1. Innovative climate	–								
2. Idea exploration	.19	–							
3. Idea generation	.36	.53	–						
4. Idea championing	.41	.46	.66	–					
5. Idea implementation	.37	.52	.78	.72	–				
6. ICAP – passive use	.19	.20	.39	.36	.41	–			
7. ICAP – active use	.23	.18	.32	.33	.37	.60	–		
8. ICAP –constructive use	.22	.20	.36	.37	.40	.55	.77	–	
9. ICAP – interactive use	.23	.20	.40	.42	.43	.56	.73	.82	–
M	3.72	4.71	4.66	4.21	4.42	3.04	2.64	2.74	2.63
SD	0.75	0.84	0.81	1.05	0.98	0.87	1.03	1.94	1.01
Min	1	2	1.67	1	1	0	0	0	0
Max	5	6	6	6	6	4	4	4	4

Note. All correlations are significant at $p < .001$

Hypothesis Testing

The tested model had acceptable fit indices: MLR $\chi^2(331)=594.490$, $p < .001$, CFI=.966, TLI=.962, RMSEA=.046 [90% CI=(.040, .052)], SRMR=.045. Figure 1 shows the relationships between the examined variables.

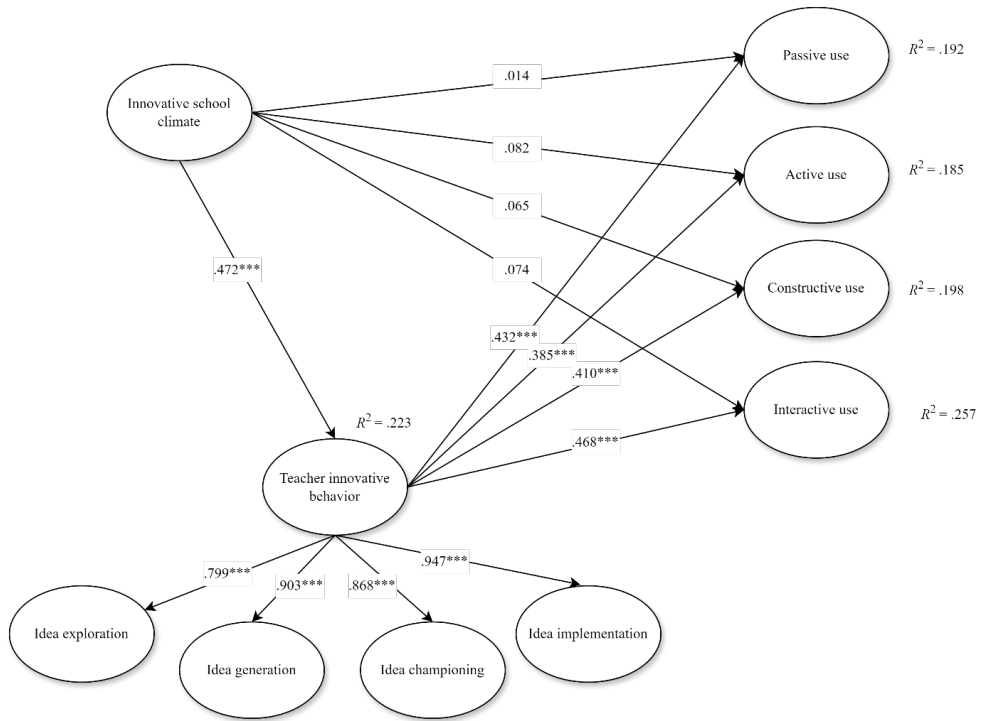


Figure 1. Path diagram of the hypothesized model.

Note. Manifest variables and factor loading are omitted. Standardized estimates are displayed. *** $p < .001$

As can be seen, the innovative school climate did not have significant direct effects on implementing technology for different types of learning activities. On the other hand, a statistically significant positive relationship was recorded between the school’s innovative climate and teacher’s innovative behavior ($\beta=.472$, $SE=0.059$, $p < .001$). Furthermore, it was found that the innovative behavior of teachers positively predicts all types of technology integration in the classroom (Figure 1).

When it comes to the effects of the innovative climate in the school via teachers’ innovative behavior, significant positive effects have been documented. It is evident in Table 2 that the indirect effects of the innovative climate on the four types of

technology use in teaching and learning were positive and of moderate strength. The constructed confidence intervals did not include zero, which indicates that the indirect effects in all four cases were statistically significant. The amount of explained variance of the outcome variables ranged from 18.5% to 25.7% (Table 3). It should be noted that out of 10,000 resamples there were 7 non-admissible solutions which can be dismissed as a non-problematic result.

Table 2. Indirect effects of innovative school climate on dimensions of technology integration in teaching and learning

Outcome variable	β	SE	95% confidence interval	<i>p</i>
Passive use	.204	0.04	[.13, .28]	< .001
Active use	.182	0.04	[.11, .26]	< .001
Constructive use	.194	0.04	[.12, .27]	< .001
Interactive use	.221	0.04	[.14, .30]	<.001

Note. The estimation of effects is based on the bootstrapping procedure with 10,000 resamples. Standardized estimates are displayed.

Table 3 shows the total effects of school innovative climate on the four dimensions of integrating technology into learning activities. The total effects were obtained by adding the direct effects of the predictor variable and the indirect effects, via teacher innovative behavior. It is evident that the total effects of a school’s innovative climate are statistically significant in all four cases. Considering the fact that teachers are nested within schools, estimated effects were verified using cluster-robust standard errors. Although the cluster-robust analysis indicated that the estimated model may not be identified, the obtained results fully confirmed the previously obtained conclusions.

Table 3. Total effects of innovative school climate on dimensions of technology integration in teaching and learning

Outcome variable	Total effect	95% confidence interval	SE	<i>p</i>	<i>R</i> ²
Passive use	.22	[.10, .33]	0.06	<.001	.192
Active use	.26	[.15, .38]	0.06	<.001	.185
Constructive use	.26	[.15, .37]	0.06	<.001	.198
Interactive use	.29	[.18, .41]	0.06	<.001	.257

Note. The estimation of effects is based on the bootstrapping procedure with 10,000 resamples. Standardized estimates are displayed.

■ DISCUSSION

While it is acknowledged that using technology can enhance the quality of instruction, it is still unclear what factors contribute to student cognitive engagement with digital technologies. Research has only recently begun to focus on the antecedents of teacher integration of technology into different types of learning activities in the classroom. The aim of the present study was to examine the relationships between the innovative climate in the school, the innovative behavior of teachers, and different types of technology use in teaching and learning.

We found that teachers' innovative behavior is positively associated with all four dimensions of technology integration in teaching and learning. The findings revealed that teachers who show innovative behavior to different extents also use technologies to various degrees for diverse classroom learning activities. It is especially important to point out that the innovative behavior of teachers more strongly predicts the use of technology in interactive learning activities than in other types of student learning tasks. This finding is consistent with previous research in which educational use of technology was operationalized and measured differently. For example, Vidergor (2023) reported that self-innovativeness of teachers is a significant predictor of practices of remote teaching. It is reasonable to assume that innovative behavior allows teachers to find different ways to engage students during their own lessons (Ucus & Acar, 2018). One possible explanation is that teachers who are prone to innovative thinking and behavior tend to engage more often in responsible teaching that includes careful monitoring of student progress and effective lesson planning (Orakcı et al., 2020). In addition, it seems that how teachers perceive the potential benefits and ease of using technology in their work depends on their innovativeness (Mazman Akar, 2019). Our results extend existing knowledge by indicating that innovative behavior predicts not only teachers' technology acceptance, but also qualitatively different ways of using it.

Innovative climate had a positive predictive effect on teachers' innovative behavior. From the perspective of the theory of planned behavior (Ajzen, 2020), this finding is completely expected. According to this theory, an innovative climate in the school has the role of a subjective norm that influences teachers' individual behavior. In other words, when teachers perceive that school leaders and staff members encourage the introduction of innovations, it creates social pressure on them to behave innovatively themselves. Similar findings were also found in other educational contexts (Chou et al., 2019).

One of the key findings of our study is that an innovative climate via teacher innovative behavior has indirect effects on the implementation of different types of learning activities involving technology. Teachers are more likely to generate and implement new ideas when they see their schools as environments conducive to such behavior. This consequently leads to more frequent design of different

types of student activities that involve technology. These findings expand previous accumulated knowledge and answer the question why school innovative climate is positively related to the application of technology in teaching and learning.

Contrary to what we anticipated, in this study, we did not find that innovation climate has direct effects on different types of technology use. This finding contrasts with some previous studies that found direct effects of innovative climate on the integration of technology in teaching and learning. We believe that the conflicting findings can be explained by the fact that the educational implementation of digital technologies has been modeled in different ways. It should be noted that Ninković et al. (2023) reported that individual perceptions of innovative climate at school positively predict different ways of using technology operationalized in accordance with the ICAP framework. However, the mechanisms that mediate the relationship between school innovative climate and technology-supported teaching were not analyzed in this study. Given the inconsistent empirical evidence, more research is needed to draw conclusions about the nature of the effects of school innovative climate on the use of technology in teaching.

The findings of this research highlighted the role of teachers' innovative behavior in enhancing different types of technology implementation in teaching. Furthermore, our study showed that the innovative behavior of teachers is significantly related to school innovative climate. Beliefs about the school climate have the role of a reference standard that directs the individual behavior of teachers. From these findings comes the conclusion that the providers of professional learning programs for school principals should pay attention to behaviors that serve to encourage an innovative climate and the innovative behavior of teachers.

Several limitations of this study should be noted. First, the conceptual limitation stems from the fundamental assumption of the ICAP theory that externalizing behavior of students is a reliable indicator of their cognitive engagement. Some scholars (Thurn et al., 2023) argue that solely by observing overt behaviors, it is not possible to determine the effectiveness of a student's learning. Second, the participants in our study were not recruited randomly, so it is not reasonable to claim that the sample represents the entire population of teachers in Serbia. In addition, the data were collected only in Serbia, so it would be good to reiterate similar research in other educational contexts. Finally, only the path from the school climate through innovative behavior of teachers to the integration of technology in different types of learning activities was tested in this study. Future studies, grounded in theory, need to test other mediators that potentially convey the effects of school climate on ways of using technology in teaching and learning.

■ CONCLUSION

Schools worldwide are facing the challenge of how to better utilize the potential of digital technologies in cognitively engaging students. In this context, the present study sheds light on the relationship between innovative school climate, teacher innovative behavior, and the educational use of digital technology. Our findings reveal that an innovative school climate directly promotes teacher innovative behavior, which has positive effects on technology-supported teaching and learning. Importantly, our study underscores that, in addition to teachers' professional competences, organizational school characteristics have a pivotal role in integrating technology into learning activities. The results have implications for practice in terms of creating innovative school environments, supporting teachers' innovative behavior, and using technology in ways that enhance student learning.

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