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# Fostering pre-service teachers' technology acceptance – does the type of engagement with tool-related information matter?

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**Abstract**
Pre-service teachers' often suboptimal use of technology in teaching can be explained by low levels of technology acceptance. The present study aims to investigate how technology acceptance can be promoted. Based on the Technology Acceptance Model by Davis (1986), we hypothesized that encouraging pre-service teachers to constructively engage with rather than passively reading tool-related information should increase their assessments of the tool's perceived usefulness, perceived ease of use, intention to use and actual use in lesson plans. In an experimental study, $N = 53$ pre-service teachers were either asked to read a blog post about the potential of a mind mapping tool (passive condition) or to work on small tasks covering the same information as the blog post (constructive condition). Finally, all participants were instructed to develop lesson plans. Contrary to our hypothesis, analyses of variance showed that passive engagement had stronger positive effects on technology acceptance than constructive engagement, i.e., reading a blog post significantly increased pre-service teachers' perceived ease of use (partial $\eta^2 = .15$) compared to working constructively on open-ended tasks ($p < .01$). Exploratory analyses indicated that deeper engagement with the tasks in the constructive condition was associated with lower technology acceptance ($r = [-.37; -.27]$, $p < .05$). Nevertheless, both conditions yielded a significant increase in intention to use over time, indicating that engagement with information about a tool in general can foster pre-service teachers' technology acceptance.

**Keywords** Interactive-Constructive-Active–Passive (ICAP) framework · Technology acceptance · Cognitive engagement · Pre-service teachers · Higher education

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## 1 Introduction

Digital technology has great potential to facilitate student learning in the classroom. For example, quiz apps can increase engagement and positively influence learning outcomes (Sung et al., 2016). However, teachers only partially make use of such technology affordances: Sailer et al. (2021) showed that they initiate mostly passive learning activities with digital technology, such as showing digital presentations to their students. Consequently, the potential of digital technology is often not fully exploited, partly because tools that hold particular promises to support learning, such as collaboration tools (e.g., Jeong et al., 2019) or animations (Berney & Bétrancourt, 2016), are hardly used (Marcelo et al., 2015; Schmid et al., 2017).

In the past two decades, researchers have sought to determine what prevents teachers from effectively using digital technology in the classroom (e.g., Eickelmann & Vennemann, 2017; Ertmer & Ottenbreit-Leftwich, 2010). For example, low professional knowledge or a lack of equipment can hinder teachers from using digital technology in a way that is beneficial for learning (Gerthofer & Schneider, 2021; Joo et al., 2018; Pamuk, 2012). Also, low technology acceptance can negatively affect the use of digital technology (Backfisch et al., 2021). Unfortunately, though, teachers often show unfavourable attitudes towards learning with digital technology, as demonstrated by the International Computer and Information Literacy Study by Fraillon et al. (2019).

Therefore, it is crucial to investigate how teachers' technology acceptance can be facilitated in pre-service teacher (students pursuing a degree in teacher education/prospective teachers) education courses. So far, intervention studies targeting pre-service teachers' technology acceptance are rare (Kale, 2018). The objective of this study was to determine how pre-service teachers' technology acceptance can be promoted through different kinds of engagement with information about a particular digital tool. Oftentimes, teachers learn about new tools from other teachers or discover them on the internet. Yet, from the perspective of the Interactive-Constructive-Active–Passive (ICAP) framework by Chi and Wylie (2014), who divide learning engagement into interactive, constructive, active and passive activities, this kind of exposure to information is rather unfavourable, as teachers usually process such information only superficially. For this reason, we wondered how a more constructive engagement (e.g., through solving small assignments related to the tool in question; Chi & Wylie, 2014) with information about tools can lead to higher technology acceptance and foster greater use of digital tools in the classroom. More precisely, we investigated whether having pre-service teachers engage in different learning activities (passive vs. constructive; see Chi & Wylie, 2014) while interacting with information on a particular digital tool (measurably) affected technology acceptance and use.

## 2 Teachers' technology acceptance

Digital technology has become an integral part of society and has also affected the educational sector. State educational bodies, for example, insist on the increased integration of digital technology, as students should be adequately prepared for the digital world (for OECD countries, see van der Vlies, 2020). A further argument is that digital tools can support teaching and learning in a variety of ways, such as by using multiple forms of representation to visualize content, supporting adaptive teaching based on students' different prior knowledge levels, or enabling collaborative learning (Irion & Scheiter, 2018). However, various findings indicate that the use of digital technology does not necessarily lead to more positive learning outcomes. For example, Baker et al. (2018) investigated whether the use of PowerPoint leads to higher knowledge acquisition than a traditional setting with identical content. For this purpose, reviewing empirical research on this topic, they examined forty-eight studies and found no significant differences regarding knowledge acquisition. At the same time, the studies vary strongly in terms of effects on knowledge gain. For this reason, it does not seem to be whether a tool is used or not that makes the difference, but rather the quality of its use (Backfisch et al., 2021; Baker et al., 2018; Wekerle et al., 2022).

Many studies have examined the factors that influence the high-quality use of digital technology in the classroom (e.g., Butler & Sellbom, 2002; Eickelmann & Vennemann, 2017; Ertmer & Ottenbreit-Leftwich, 2010). A well-known model of determinants of whether users consider using technologies is the technology acceptance model by Davis (TAM; 1986). It was deduced from established psychological theories such as the theory of reasoned action (Fishbein, 1979) and the theory of planned behaviour (Ajzen, 1991). Since its development, it has been applied, modified and extended in numerous studies. By now, it has a leading role among the models for explaining the acceptance or rejection of digital technologies (Marangunić & Granić, 2015; Scherer et al., 2019). The model points to users' perceived usefulness and perceived ease of use of a technology as relevant factors that influence both the intention to use a certain digital technology and its actual use, with perceived ease of use assumed to have a direct influence on perceived usefulness (see Fig. 1).

Davis (1986) defined *perceived usefulness* as the degree to which users believe that using a particular technology would enhance their job performance. Scherer et al. (2015) showed that teachers found tools useful that promoted learners' interest and learning outcomes. In contrast, *perceived ease of use* is defined as the degree to which the person believes that using a particular technology would be effortless (Davis, 1986), for example, whether a teacher finds the user interface of a tool easy to understand. Both beliefs have been hypothesized to be directly influenced by external variables (Venkatesh & Davis, 2000), such as system features or user

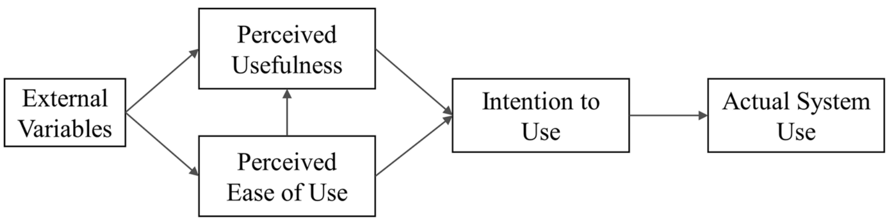



**Fig. 1** Technology acceptance model (Venkatesh & Davis, 1996)

training (Chuttur, 2009; Venkatesh & Davis, 1996). Furthermore, as an outcome variable, TAM usually examines *intention to use*, which should in turn influence *actual use* of the tool (Scherer et al., 2019). In the case of teachers, the intended behaviour would be using the tool in future lessons. The actual behaviour, in contrast, refers to the extent to which they actually use the tool in the classroom.

Even though the correlations among the components perceived usefulness, perceived ease of use and intention to use have been empirically validated numerous times, the association between intention to use and actual use has been investigated less often (Nistor, 2014), probably due to its more complex assessment through classroom observations, for example. In contrast, a more feasible indicator of actual use would be to investigate teachers' lesson plans (Willermark, 2018), as actual behaviour in a lesson is usually based on a pre-determined lesson plan (König et al., 2020). In addition, intention to use a tool refers more generally to the intention to use a tool in future teaching, which does not necessarily mean that it will be implemented as there are still several steps to be taken, such as identifying a suitable place in the curriculum and aligning it with its content. In contrast, lesson plans indicate that such steps have already been partially taken because one has decided to integrate the tool into the lesson plan. Thus, lesson plans can provide a good approximation of intended behaviour.

Empirical research has mainly confirmed the different effects and associations assumed in TAM (e.g., Joo et al., 2018; Scherer & Teo, 2019). In a study by Ma et al. (2005), an extended form of the TAM with perceived usefulness, perceived ease of use, and subjective norm (i.e., perceived social pressure to perform a certain behaviour; Teo, 2011) explained about 43% of the variance in intention to use among pre-service teachers. Similarly, Teo et al. (2009) found that TAM (perceived usefulness, perceived ease of use and attitude towards computers) explained 27% of the variance in pre-service teachers' intention to use technology (Teo et al., 2009). Scherer et al. (2019) further found in a meta-analysis that TAM is applicable to both pre- and in-service teachers. For example, Sadaf et al. (2016) investigated predictors of pre-service teachers' intention to use and actual use of Web 2.0 applications in a two-phase, sequential explanatory design with surveys ($N = 189$) and interviews ($N = 12$). They found that perceived usefulness was one of the strongest predictors of intention to use and actual use of Web 2.0 applications. In addition, there was a significant positive relationship between intention and subsequent behaviour among pre-service teachers (Sadaf et al., 2016). In a study by Yuen and Ma (2008), however, perceived ease of use was the only factor to significantly predict intention to use.

### 2.1 Fostering pre-service teachers' technology acceptance through constructive engagement with tool-related information

As described, prior research points to the importance of technology acceptance of digital tools for their actual use in the classroom. So far, however, research on how to positively influence the perceived usefulness and perceived ease of use of (educational) technology, especially among pre-service teachers, is scarce (Kale, 2018).

When teachers encounter digital tools to be used in the classroom, they often do so on the Internet. For instance, there are websites and blogs that contain texts or videos that provide arguments for the effectiveness and usability of a given digital tool, such as "www.edutopia.org". In terms of TAM, such websites are typically designed in a way that is intended to facilitate the perceived ease of use and perceived usefulness of the tool, for example by having other teachers report on their positive experiences with the tool.

From an instructional perspective, however, it is questionable whether reading about the alleged advantages of a tool will be powerful enough to positively influence the perceived usefulness and perceived ease of use of this tool by a potential user. Based on the ICAP framework by Chi and Wylie (2014), it might be expected that having learners passively receive information about digital tools is less effective than engaging them to interact with that information more actively, for example by having them sort and weigh information about the tool in terms of its usefulness and ease of use.

More specifically, the ICAP framework defines different modes of cognitive engagement activities according to students' overt behaviour. It proposes that engagement behaviour has four modes: passive, active, constructive, and interactive (Chi & Wylie, 2014). The ICAP hypothesis states that the more students move from passive to interactive activities, the more they will learn. The reason for this is that each mode corresponds to a different set of underlying knowledge change processes that are most likely to occur within that mode. In turn, these knowledge change processes differ in their strength of association with a deep understanding of the learning material. Reading a website or blog post about the use of a digital tool, for example, corresponds to a *passive* learning activity. According to ICAP, when a learner is passive, the received information is typically stored in an isolated fashion and not well integrated with existing prior knowledge (Chi & Wylie, 2014). In an *active* mode of engagement, learners manipulate the material, for example, by marking passages in the text about the potential benefits of a tool. This should activate prior knowledge and allow existing schemata to be completed. ICAP assumes that the new knowledge can then be applied in similar contexts, and typically, there should be at least a superficial understanding (Chi & Wylie, 2014). When learners engage in *constructive* learning activities, they create content that goes beyond the existing materials. This applies, for example, to a situation in which a learner draws a concept map about different aspects of using the tool, takes notes in their own words, or explains concepts. As a result, constructive activities are assumed to induce inference processes that can result in a deeper understanding and transfer of the learning material (Chi & Wylie, 2014). Finally, being *interactive* requires learners to refer to other learners' ideas, for example by discussing the pros and cons of a digital tool with a partner or in small groups. This enables them to generate new knowledge through interaction and the opportunities for sharing feedback or ideas that come with it. According to the model, this activity has the potential to generate in-depth understanding of the learning material.

It is important to understand that Chi and Wylie (2014) do not assume a deterministic correlation between overt behaviour and cognitive processes. In other words, there can be instances in which high-level cognitive processes occur during passive activities, and low-level cognitive processes occur during interactive activities. Nevertheless, Chi and Wylie (2014) justify the ICAP hypothesis with numerous reanalyses of studies on the effects of various types of experimental conditions on domain-specific knowledge acquisition. For example, the authors examine studies in which learners took notes or created concept maps and then categorised this condition as constructive. In this way, about 40 studies were reanalysed and interpreted as a comparative study of various engagement modes that supported the ICAP hypothesis. For example, in an empirical study, Menekse et al. (2013) investigated the effects of all four modes of engagement on learning outcomes in a learning unit on atomic bonds and crystal structures. Results showed that students' knowledge increase from a pre- to a post-test was significantly higher in the constructive condition, in which students were instructed to interpret a diagram that contained information from a text, compared to a passive condition (in which students only read the text).

In terms of TAM, the model does not specify what role teachers' professional knowledge plays in their technology acceptance and technology use, although it has an important function in incorporating and integrating digital technology into lessons in a sophisticated way. This also has not yet been investigated in previous research. However, professional knowledge (e.g., technological pedagogical content knowledge, Koehler & Mishra, 2009) can also matter in determining whether and to what extent digital tools are accepted by teachers. This is because teachers rely on their knowledge to decide whether a tool is beneficial for learning success and should therefore be used (Archambault & Crippen, 2009; Mailizar et al., 2021; Scherer et al., 2019). Not only do teachers need knowledge about students' psychological processes and knowledge about the learning content, they also need technological knowledge about how to work with and apply digital tools. Even though the ICAP model does not focus on the effects of different kinds of activities on attitude change, but rather on knowledge acquisition, more comprehensive professional knowledge can be related to teachers' technology acceptance. Several studies suggest that professional knowledge predicts perceived usefulness and perceived ease of use (Hsu, 2016; Joo et al., 2018; Scherer et al., 2019). Therefore, engagement in constructive activities targeting professional knowledge (such as knowledge about potential benefits of using the tool, usage scenarios for the tool, etc.) can be more beneficial for reaching higher levels of perceived usefulness, perceived ease of use, and intention to use than engagement in passive activities. Thus, this study compared the effects of encouraging passive vs. constructive learning activities on the technology acceptance of pre-service teachers.

### 2.2 Research questions and hypotheses

In this experimental study, we provided pre-service teachers with information about a specific digital tool that could be used in the classroom to support student learning. We then created two experimental conditions: In one condition, students read a blog post about the tool (passive condition), while students in the other condition were instructed to perform six simple constructive tasks covering the same information as the blog post. Afterwards, all students were instructed to develop lesson plans.

Our first research question was: Do the connections of the TAM model hold true with regard to the use of the tool in their lesson plans, which in turn is affected by intention to use it? Based on prior research, we assumed that perceived usefulness predicts intention to use (H1), perceived ease of use predicts intention to use (H2), perceived ease of use predicts perceived usefulness (H3) and intention to use predicts actual use in lesson plans (H4).

Our second research question was: To what degree does encouraging learners to engage in constructive activities while learning about the potential of a certain digital tool (compared to passive activities) have a positive effect on pre-service teachers' (1) perceived usefulness, (2) perceived ease of use, (3) intention to use and (4) actual use in lesson plans of the technology?

Based on ICAP, we assumed that because constructive activities should result in deeper processing of information about the tool than passive activities, encouraging pre-service teachers to engage in constructive compared to passive learning activities should contribute to higher perceived usefulness (H5), higher perceived ease of use (H6), an increased intention to use the tool (H7), and an increased actual use of the tool in lesson plans (H8). In addition, we exploratively investigated to what extent the quality with which the tasks were completed would be related to technology acceptance.

## 3 Method

### 3.1 Participants and design

Students took part in an online experiment embedded in a psychology lecture-based course at a German university which was compulsory for all teacher education students. They received course credit for participation. To compare two modes of engagement with information about a digital tool based on the ICAP Model, we established a $1 \times 2$ between-subjects design, with students randomly assigned to a passive or constructive condition ($N_{\text{passive}} = 25$, $N_{\text{constructive}} = 28$). Participants in the two conditions were asked to carry out either one passive or several constructive tasks related to a specific digital classroom tool. These tasks were informationally equivalent to the blog post. Subsequently, all participants were asked to develop lesson plans.

Students were 21 years old on average ($M_{\text{Age}} = 21.4$, $SD_{\text{Age}} = 4.2$). The majority of our participants were in their second semester of university ($M_{\text{Sem}} = 1.9$, $SD_{\text{Sem}} = 1.0$) and mostly female (approximately 69.8%). Most participants were enrolled in a teacher education program for high school teachers (25%), followed by middle school teachers (14%), elementary school teachers (8%), and lastly secondary school teachers (5%).

### 3.2 Procedure

After completing a survey that asked for demographic data, all participants received basic information about an online collaborative mind mapping tool, called "Coggle" (Version 1.0, Coggle, 2023). The tool's user interface and an example mind map that was created with Coggle were shown. As a short description of its features, it was stated that Coggle can be used to generate collaborative mind maps in real time. This way, participants could get a rough idea of the tool, even if they were not familiar with it yet. After that, they were asked to rate the perceived usefulness of Coggle, its perceived ease of use and their intention to use it.

In a next step, all participants read a one-page text about the ICAP framework to help them understand the subsequently presented learning-related benefits of the tool. Then, participants in the *passive* condition were asked to read a blog post by a fictitious teacher who described his personal experiences working with the tool and who addressed its usefulness by referencing the ICAP framework. In the *constructive* condition, participants worked on six mostly open-ended exercises that covered the same information as the blog post. Here, we paid precise attention to informational equivalence by developing the tasks in such a way that they corresponded exactly to the paragraphs in the blog post. Since this information had to be generated by the students themselves in the constructive condition, we also made sure that the tasks were not too challenging. For example, the first task presented students with a labelled illustration of the user interface of the tool, and participants were instructed to inspect the illustration and to describe the illustrated functions of the tool in a text field in their own words (see Fig. 2).

In the blog post that the passive group received, the labelled illustration was also shown, but the functions were already described in full sentences by the author of the post. Furthermore, in a second task, a diagram from an article by Menekse et al. (2013) about scores on a performance test after carrying out different learning activities was presented. The constructive group was instructed to interpret the graph in their own words based on the ICAP model. The same graph was also included in the blog post (see Fig. 3).

There, the fictitious teacher wrote about the results of the study and described the graph. In another task, participants in the constructive condition were instructed to develop usage scenarios for the tool based on the ICAP model, whereas participants in the passive condition read about usage scenarios identified by the fictitious teacher in the blog post. In order to check whether the learners in the constructive condition actually generated the corresponding knowledge, the quality with which participants completed the first three tasks was also assessed. In the posttest, participants rated Coggle's perceived usefulness and perceived ease of use, as well as their intention to use Coogle again. Finally, they were instructed to develop lesson plans.

### 3.3 Variables

**TAM components** The scales used to measure perceived usefulness, perceived ease of use and intention to use were adapted from Hu et al. (2003), Teo (2011) and Venkatesh et al. (2003) and were reformulated to fit "Coggle". Before and after the intervention, participants were asked to rate Coggle's perceived usefulness (5 items, e.g., „Using Coggle would enhance my job performance ", Cronbach's $\alpha = 0.90$–93), perceived ease of use (5 items, e.g., „I find it easy to get Coggle to do what I want it to do ", Cronbach's $\alpha = 0.75$–91), and their intention to use Coggle in the future

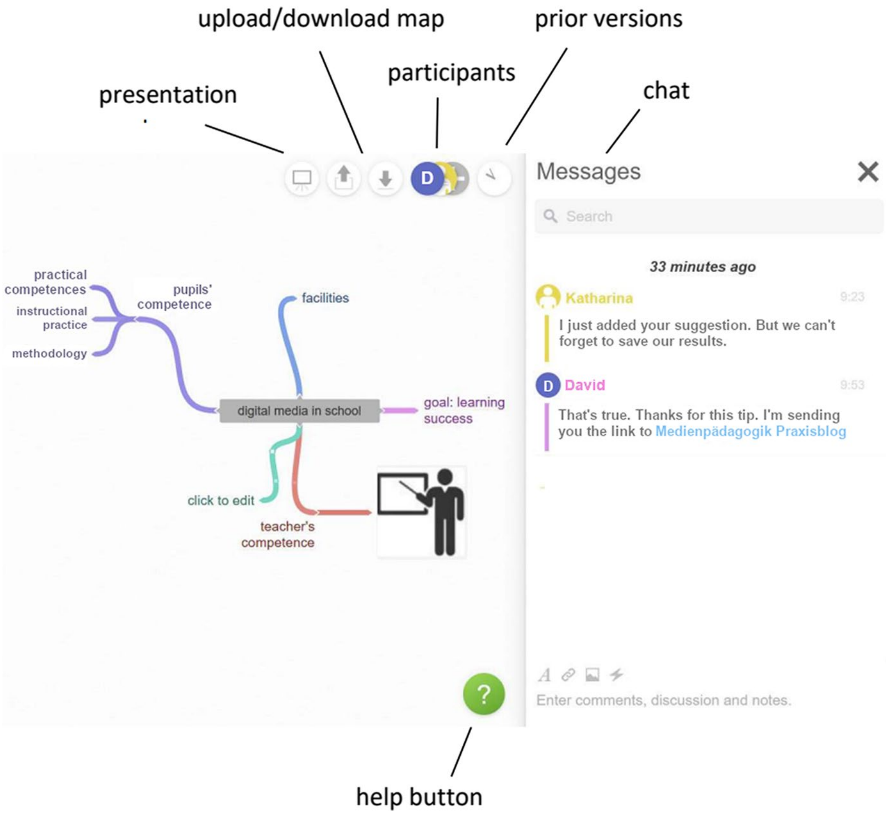



**Fig. 2** Illustration of the tool's user interface

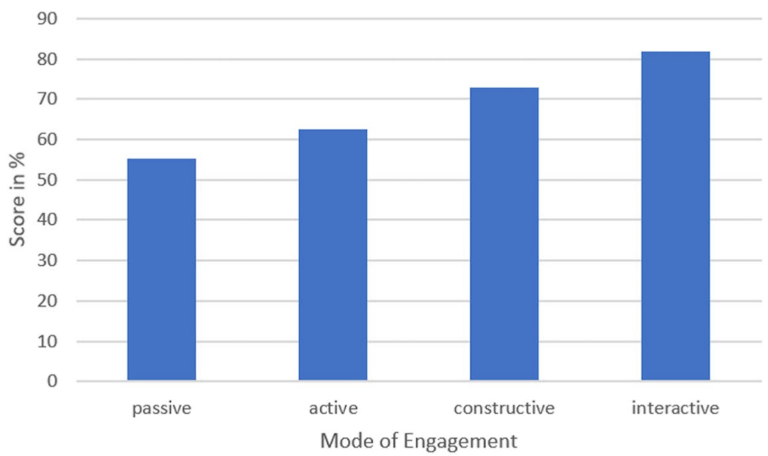



**Fig. 3** Diagram of learning activities and test performance (Menekse et al., 2013, p. 363)

(4 items, e.g., „I intend to use Coggle in my lessons in the future", Cronbach's $\alpha = 0.84$–$0.88$) on a Likert scale from (1) do not agree to (4) totally agree.

**Lesson plan use** As an indicator of actual use, participants were instructed to develop lesson plans. For each activity, they were asked to provide a title and elaborate on what the teachers and students would ideally do in that part of the lesson. These were classified according to whether the tool "Coggle" or "mind map" was used (interrater-agreement Cohen's $\kappa = 1.00$). Each activity in the lesson plan in which the tool was used was coded with 1. If the tool was not used, the activity was coded with 0. The sum across all included activities then formed the variable capturing the frequency of use of the tool within participants' lesson plans.

**Task performance (constructive condition only)** In order to examine the connection between performance in the tasks in the constructive condition and technology acceptance, participants' task solutions were evaluated by comparing them to an expert solution. A corresponding scoring system was used. For example, in the first task where learners were asked to name the functions of the tool, one point was awarded for each function they mentioned. Afterwards, scores on the first three tasks were added up to create a total score describing the quality of task completion. In total, participants could achieve a maximum score of 26 points on the three tasks.

### 3.4 Statistical analyses

To answer RQ1, we investigated to what extent we could replicate earlier findings on the relations between perceived usefulness, perceived ease of use, intention to use, and lesson plan use. Due to the small sample size, the mean values of the scales were treated as manifest variables, and a manifest path model was calculated by aid of the statistical package Lavaan within the R software environment (Rosseel, 2012). A maximum likelihood estimation with robust estimation of standard errors and Yuan-Bentler scaled $\chi^2$ test statistic in case of violation of normal distribution was used (Werner, 2015).

To examine RQ2 and Hypotheses H5, H6 and H7, we performed three separate mixed ANOVAs with perceived usefulness, perceived ease of use and intention to use as dependent variables. The condition represented the between-subjects factor (passive vs. constructive), whereas the within-subjects factor was time (pre- vs. posttest). With respect to Hypothesis 8, the two groups again represented the independent variable (passive vs. constructive) and the use of the tool in lesson plans was the dependent variable. Accordingly, differences between the groups regarding use of the tool in lesson plans were examined using a t-test. Pearson correlations of the performance score with perceived usefulness, perceived ease of use and intention to use were calculated in order to exploratively investigate connections between task performance and technology acceptance. The alpha level of these analyses was set to 5%.

# 4 Results

## 4.1 RQ1: Relations between perceived usefulness, perceived ease of use, intention to use and lesson plan use

We first investigated whether the predictions made by TAM would be observable in our data as well. A manifest path model (see Fig. 4) showed a very good fit to the data, $df = 2$, $\chi2 = 1.35$, $p = 0.50$, RMSEA = 0.000, CFI = 1.000, TLI = 1.024, SRMR = 0.019. The results support all assumed associations (H1, H3, and H4) except for perceived ease of use predicting intention to use (H2). Intention to use functioned as a significant predictor for pre-service teachers' use of the tool in their lesson plans (H4).

## 4.2 RQ2: Effects of engagement in passive vs. constructive activities on perceived usefulness, perceived ease of use, intention to use and lesson plan use

Figure 5 illustrates descriptive statistics for perceived usefulness, perceived ease of use and intention to use for both conditions. Concerning H5, descriptively, in both conditions, the means were higher at posttest than at pretest, and learners in the passive condition generally (i.e., at both pre- and posttest) displayed higher perceived usefulness values than learners in the constructive condition.

A mixed ANOVA with condition (passive vs. constructive) as between- and time as within-subjects factor did not reveal a significant interaction for perceived usefulness, $F(1,51) = 1.15$, $p = 0.29$, partial $\eta^2 = 0.02$. A main effect of condition was only significant on a 10% level. Surprisingly, this was in favour of participants in the passive condition, $F(1, 51) = 3.04$, $p = 0.087$, partial $\eta^2 = 0.06$. However, the increase in perceived usefulness over time was significant for both conditions, $F(1, 51) = 9.38$, $p = 0.004$, partial $\eta^2 = 0.16$.

Regarding H6, Fig. 5 illustrates that perceived ease of use increased over time for both conditions, again with a more pronounced increase from pre- to posttest in the passive condition. Subsequently, a mixed ANOVA with condition as between-subjects factor, time as within-subjects factor, and perceived ease of use as dependent

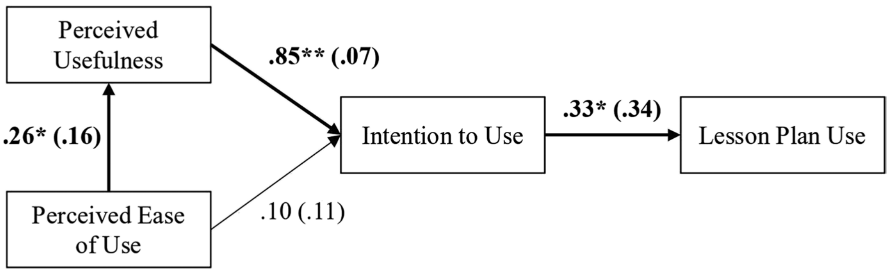



**Fig. 4** Results of path modelling the effects of perceived usefulness, perceived ease of use and intention to use on lesson plan use. *Note*. Standardized coefficients are presented, with standard errors in parentheses. $^*p < 0.10$, $^{**}p < 0.001$

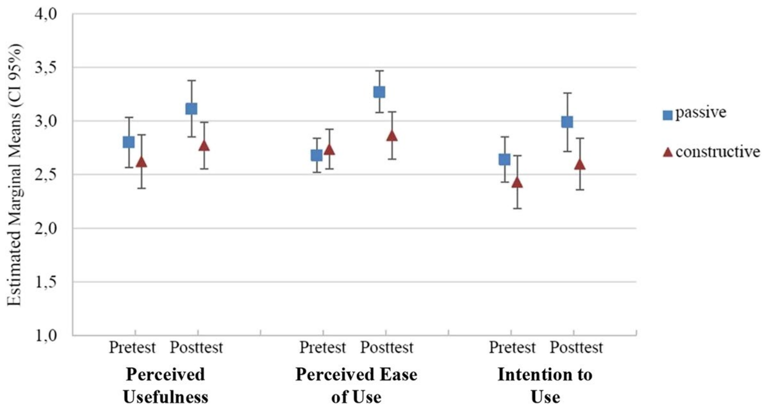



**Fig. 5** Means and 95% confidence intervals of perceived usefulness, perceived ease of use and intention to use by mode of engagement

variable revealed a significant interaction effect, $F(1, 51) = 8.88$, $p = 0.004$, partial $\eta^2 = 0.15$, albeit in an unexpected direction. The simple main effect of condition was significant in the posttest, partial $\eta^2 = 0.14$, $p = 0.006$. The simple main effect of time was significant in the passive condition, $F(1, 24) = 44.95$, $p < 0.001$, partial $\eta^2 = 0.65$, but not in the constructive condition, $F(1, 27) = 1.08$, partial $\eta^2 = 0.04$, $p = 0.31$.

With respect to H7, Fig. 5 shows that intention to use descriptively increased over time in both conditions. A mixed ANOVA with condition as between-subjects factor, time as within-subjects factor and intention to use as dependent variable did not result in a significant interaction ($F(1, 51) = 1.15$, $p = 0.25$, partial $\eta^2 = 0.03$). However, the main effect of condition was significant, $F(1, 51) = 4.05$, $p = 0.05$, partial $\eta^2 = 0.07$, with students in the passive condition displaying a higher level of intention to use than students in the constructive condition. There was a significant increase of intention to use over time for both conditions ($F(1, 51) = 11.45$, $p = 0.001$, partial $\eta^2 = 0.18$).

With respect to H8, participants in the passive condition used the tool more frequently in their lesson plans than participants in the constructive condition. A t-test showed no differences between the passive and the constructive condition with respect to lesson plan use, $t(51) = 1.56$, $p = 0.13$, Hedges' $g = 0.42$.

### 4.3 Exploratory analyses

Initially, based on the ICAP model, we expected that constructive activities would lead to higher technology acceptance than passive learning activities due to a deeper engagement with the information about the tool in the constructive condition. Thus, the superiority of the passive over the constructive condition (significantly at least with respect to perceived ease of use; descriptively also with respect to perceived usefulness, intention to use, and lesson plan use) was rather unexpected. Therefore, we wondered to what extent participants in the constructive condition actually engaged in constructive activities when dealing with the tasks they received, as prompting students alone may not necessarily lead them to actually engage in the intended activities (Chi & Wylie, 2014). For this purpose, as mentioned before, the tasks were scored using an expert solution. Interestingly, in all tasks, engagement in constructive activities was significantly negatively related with perceived ease of use, perceived ease of use and intention to use in the posttest ($r = [- 0.37; - 0.27]$, $p < 0.05$). This indicates that deeper engagement with the constructive tasks was associated with lower technology acceptance at posttest.

## 5 Discussion

The present study investigated the effects of prompting pre-service teachers to engage in passive and constructive learning activities on their acceptance of a particular kind of educational technology. Based on the ICAP framework by Chi and Wylie (2014), we assumed that constructive engagement with learning material about the digital tool would result in higher technology acceptance and use than engagement in passive activities based on the tool-related information. However, our results contradict these hypotheses.

Our first research question focused on determining whether the associations within the TAM model hold true for use of the tool in lesson plans as another dependent variable alongside intention to use. We assumed that perceived usefulness predicts intention to use (H1), perceived ease of use predicts intention to use (H2), perceived ease of use predicts perceived usefulness (H3), and intention to use predicts actual use in lesson plans (H4). Regarding our first research question, we found that intention to use a tool significantly predicted use of the tool in lesson plans (H4). Yet, our data do not completely support the assumptions of the TAM, as we found no evidence that perceived ease of use predicts intention to use (H2). Previous findings concerning the relation between intention to use and perceived ease of use have yielded contradictory results concerning this relation as well (Teo et al., 2018; Yuen & Ma, 2008). Also, the effect of perceived ease of use might be mediated by another variable, i.e., attitude towards the tool (e.g., Huang & Teo, 2020; Moses et al., 2013). Nevertheless, the indirect effect of perceived ease of use on intention to use via perceived usefulness (H1) indicates some relevance of perceived ease of use. These results support the general assumption that perceived usefulness is a more dominant predictor of intention to use than perceived ease of use (Scherer et al., 2019).

In our second research question, we asked to what degree constructive learning activities while learning about the potential of a certain digital tool (compared to passive activities) have a positive effect on pre-service teachers' (1) perceived usefulness, (2) perceived ease of use, (3) intention to use and (4) actual use in lesson plans of technology, when compared to passive activities. We assumed that encouraging students to engage in constructive compared to passive learning activities should contribute to higher perceived usefulness (H5), higher perceived ease of use (H6), increased intention to use the tool (H7), and increased actual use of the tool in lesson plans (H8). In addition, we exploratively investigated to what extent the quality with which the tasks were completed was related to technology acceptance.

Regarding Hypothesis 5, we found no significant interaction between time and condition on perceived usefulness. Nevertheless, the significant effect of time on perceived usefulness demonstrates that participants' perceived usefulness of the tool improved significantly regardless of condition. Thus, based on this result, encouraging students to engage in constructive activities does not seem to have more pronounced positive effects on perceived usefulness than encouraging them to engage in passive activities. In this case, reading about a fictitious teacher's positive experiences regarding the usefulness of digital tools could already suffice to boost perceived usefulness in the intended direction.

Concerning Hypothesis 6, we found a significant interaction effect for perceived ease of use. Contrary to our expectations, prompting students to read a blog post had a stronger positive effect on perceived ease of use than having them work constructively on open-ended exercises. Moreover, this effect can be considered large (Cohen, 1988). That is, simply reading the blog post increased pre-service teachers' perceived ease of use. This raises the question of how the two conditions actually differ from each other, such that reading the blog post in particular led to increased perceived ease of use. The fact that the blog post was written by a fictitious teacher could have been decisive for perceived ease of use. After all, the information about the functions, benefits and learning scenarios for the tool were embedded in a narrative about the teacher's personal experiences with the tool. During constructive engagement, in contrast, the information was not shared by a specific teacher. For this reason, it is possible that pre-service teachers perceive the fictitious teacher's explanations as particularly conducive of perceived ease of use, as they stem from a (convincing) source (Petty & Cacioppo, 1986).

With respect to Hypothesis 7 on intention to use, the results show no interaction effect between condition and time. However, we observed significant main effects of time and condition. The effect of time again demonstrates that participants' intention to use improved regardless of condition. In other words, prompting either passive or constructive engagement increased students' intention to use the tool. Moreover, this effect can again be regarded as large (Cohen, 1988). We attribute this to the fact that perceived usefulness was found to predict intention to use and that we found similar positive effects of time on perceived usefulness in the previous analysis. Given that perceived usefulness increased over time and was predictive of intention to use, it is logical that intention to use also improved over time. This indicates that encouraging pre-service teachers to engage in either activity is helpful to foster intention to use.

Furthermore, regarding H8, a t-test showed no significant differences in lesson plan use between the two conditions. As lesson plan use is the most distal variable in TAM, this result is too not surprising. At the same time, stronger interventions with larger samples might lead to significant differences between the conditions.

However, it is still noteworthy that there was a significant increase in perceived usefulness and intention to use in both conditions. This indicates a positive development through both passive and constructive engagement with information about the tool. Thus, pre-service teachers seem to be quite open to new tools and ready to engage with them when given information about them. The initially unexpected results regarding the greater improvement in the passive condition could be explained in several ways related to the assumptions of the ICAP model: First, Chi and Wylie (2014) state that the model may not be suitable for all domains, such as procedural domains. Similarly, for example, knowledge of the tool's functions may not be suitable for constructive elaboration, as such characteristics are somewhat arbitrary. Furthermore, it also might depend on whether the acquired knowledge is too superficial, or the tasks are too easy, in which case no differences between activities might occur, as they might not evoke deep cognitive processing (Chi & Wylie, 2014).

In contrast, however, the constructive condition might also have imposed a high cognitive load on students, meaning that they might not have had sufficient opportunity to invest effort in elaborating the information about the tool, as the task instructions might have been too strenuous to follow. Indeed, research shows that working on complex tasks without further instructional guidance is particularly ineffective when learners have little prior knowledge (Kalyuga et al., 2001; van Gog et al., 2008), which might have been the case in our sample of (beginning) pre-service teachers. In this sense, the tasks in the constructive condition might have been too complex. In contrast, the blog post by an in-service teacher about the potential and use of the tool might be considered a worked example (Renkl, 2014) for the constructive tasks, in which participants in the constructive condition had to generate the corresponding knowledge themselves. Given that the study sample consisted of students in their second semester of studies with an arguably low level of prior knowledge, a worked example effect might have occurred in the passive condition (Renkl, 2014). Perhaps this increased knowledge acquisition about the use and potential of the tool then also led to higher technology acceptance in the passive condition.

Furthermore, the students' low level of prior knowledge was accompanied by another challenge: Students with little prior domain-specific knowledge tend to overestimate their competence (Dunning et al., 2003). If students only superficially engage with a topic, they may mistakenly think that they have already grasped the learning content, although this is not always the case (Renkl, 2001). It is possible that reading the blog post and the teacher's explanations gave the students the impression that they had already grasped the affordances of the tool. For this reason, learners in the passive condition might underestimate the challenges that could arise when using the tool and overestimate the perceived usefulness or perceived ease of use of the tool accordingly. For the constructive condition, the exploratory analyses regarding the associations between task performance and TAM might be interpreted in a similar way: If the accuracy of task completion is interpreted as an indicator of knowledge acquisition, the negative associations between better task completion and technology acceptance can indicate that students who have acquired more knowledge have lower technology acceptance, perhaps because they are better at estimating the difficulty of using the tool and may also make a more realistic judgement. In contrast, students who performed the tasks poorly potentially have lower knowledge acquisition regarding use of the tool and therefore underestimate the difficulties of use (the so-called double curse of incompetence, Dunning et al., 2003; Ehrlinger et al., 2008). Consequently, future studies should control for learners' prior knowledge or assess their cognitive load, respectively. However, applying ICAP (which actually focuses on learning processes and outcomes) to the build-up and change in attitudes might be a quite large theoretical stretch, although research at least suggests links between professional knowledge and technology acceptance (e.g., Joo et al., 2018). Perhaps taking more specific theories of attitude change into account (such as Elaboration-Likelihood-Model, Petty & Cacioppo, 1986) would be more fruitful for the design of effective interventions.

## 6 Limitations and conclusions

As a first limitation of our study, it should be noted that we exclusively used subjective data. Thus, we do not know whether students who indicated a high intention to use and use in their lesson plans would actually use the tool in their classrooms more often than students with lower levels of intention to use. Second, it must be considered that we did not include a control condition without treatment. Third, the small sample size increases the likelihood of a type II error.

Therefore, future studies should be conducted with larger samples and a subsequent investigation should assess actual use of the tool and test the sustainability of the effects. For example, a training study on an educational tool could be conducted and the actual use of the tool could be assessed again after a longer period of time. Furthermore, it is an open question whether these findings are also applicable to in-service teachers, who are more experienced and might therefore also perceive the usefulness and ease of use of the tool differently. Future studies should therefore also include in-service teachers. Also, it is uncertain whether more knowledge about the tool and its use is related to higher technology acceptance. It may be necessary to assess different types of knowledge (e.g., technological knowledge vs. pedagogical knowledge, Koehler & Mishra, 2009) and its associations with technology acceptance. In this respect, intervention studies could also target fostering different types of knowledge of teachers.

Despite these limitations, our study suggests that pre-service teachers' acceptance of educational technology can be promoted by having them engage with information about a digital tool. If an experienced teacher's accounts, such as in the form of a blog post, are particularly conducive to technology acceptance, a possible approach would be for in-service teachers to share their personal experiences using digital tools in the classroom. For example, they could report precisely on successful use scenarios and give advice on what technical requirements should be met, what outcomes can be expected in terms of student achievement, and so on. In this way, pre-service teachers' technology acceptance might potentially be promoted in a very economical way. It is also worth putting a stronger focus on digital media in teacher education curricula and, for example, design courses that bring pre-service teachers together with in-service teachers. In summary, the study points to the importance of technology acceptance for the implementation of technology in the classroom and provides initial indications of how support should look like in teacher training programs.

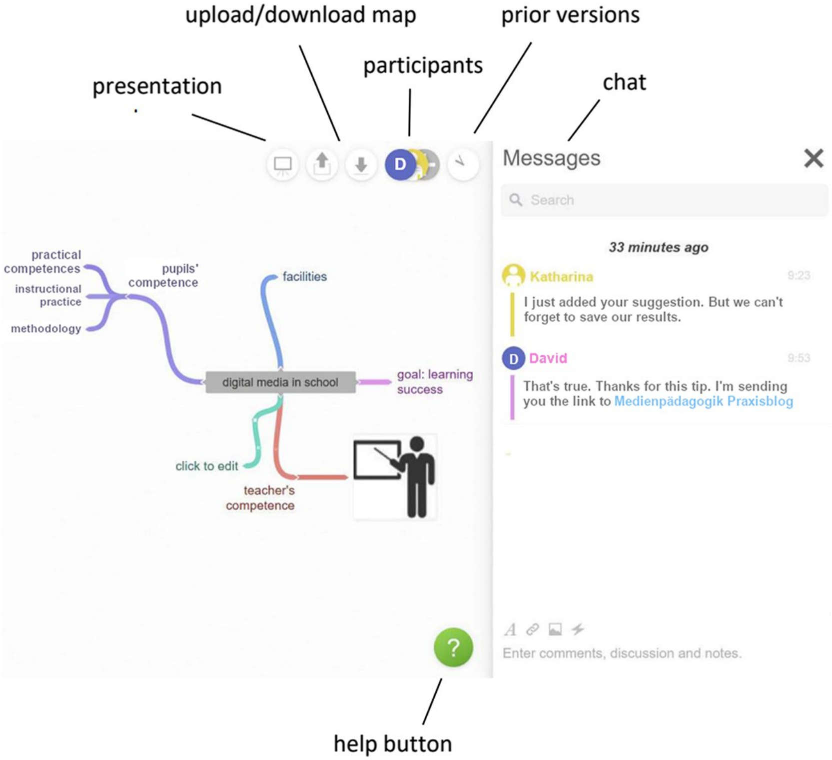
# Appendix

## Tasks of the constructive condition

1. *Task*

German: Betrachten Sie die nebenstehende Abbildung der Benutzeroberfläche von Coggle. Bitte beschreiben Sie die abgebildeten Funktionen des Tools in Stichpunkten im untenstehenden Textfeld.

*English: Look at the adjacent illustration of the Coggle user interface. Please describe the illustrated functions of the tool in bullet points in the text field below.*




2. *Task*

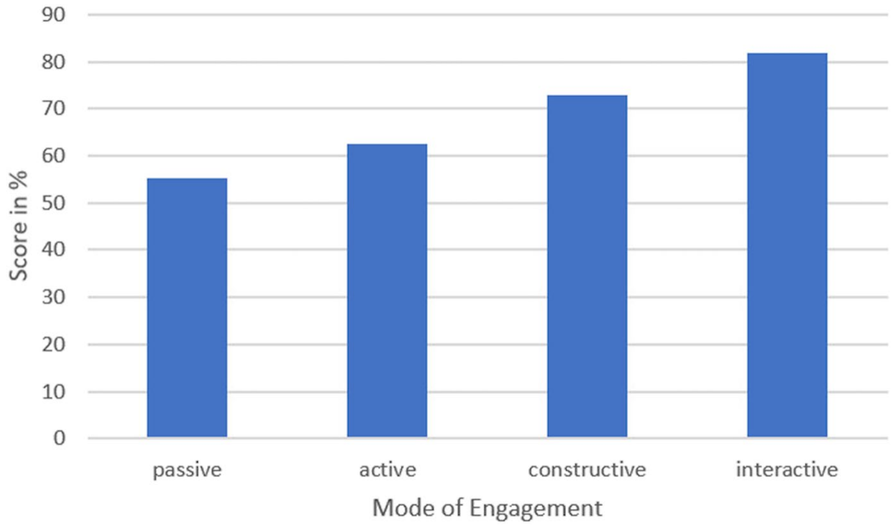
German: Wie bereits beschrieben, unterscheidet das ICAP-Modell verschiedene Arten von Lernaktivitäten (passiv, aktiv, konstruktiv, interaktiv). Unten sehen Sie eine Darstellung der Ergebnisse einer empirischen Studie von Menekse et al. (2013). In der Studie wurde untersucht, inwiefern die Art der von

Studierenden durchgeführten Lernaktivitäten einen Effekt auf den Anteil der richtigen Antworten in einem anschließend bearbeiteten Wissenstest hat.

Wie sind die Ergebnisse vor dem Hintergrund des ICAP-Modells zu interpretieren? Bitte antworten Sie in 2–3 Sätzen.

*English: As described earlier, the ICAP model distinguishes between different types of learning activities (passive, active, constructive, interactive). Below is a representation of the results of an empirical study by* Menekse et al. (2013). *The study examined the effects of each type of learning activities students engaged in on the percentage of correct answers in a subsequent knowledge test.*

*How should the results be interpreted in light of the ICAP model? Please answer in 2–3 sentences.*




3. *Task*

German: Ordnen Sie die folgenden Einsätze von digitalen Medien entsprechend Ihrer Effektivität vor dem Hintergrund des ICAP-Modells.

Ziehen Sie dafür bitte die Optionen mit der Maus in die Spalte nach rechts und ordnen Sie die Szenarien absteigend nach der Wahrscheinlichkeit für Lernerfolg (oben: höchster Lernerfolg für die Schüler(innen) – unten: niedrigster Lernerfolg für die Schüler(innen)):

*English: Rank the following uses of digital media according to their effectiveness in the context of the ICAP model.*

*To do this, please drag the options with the mouse to the column on the right and rank the scenarios in descending order according to the probability of learning success (top: highest learning success for the students—bottom: lowest learning success for the students):"*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Vortrag der Lehrperson mit einer PowerPoint<br>*Lecture by the teacher using PowerPoint* | O | O | O | O | O |
| Erstellen einer Zusammenfassung als Hausaufgabe<br>*Creating a summary as homework* | O | O | O | O | O |
| Gemeinsames Diskutieren über eine Mindmap<br>*Joint discussion about a mind map* | O | O | O | O | O |
| Markieren von Textstellen<br>*Highlighting text passages* | O | O | O | O | O |
| Die Sortierung von relevanten Aspekten durch die Schüler(innen)<br>*Sorting of relevant aspects by the students* | O | O | O | O | O |

4. *Task*

German: Bitte denken Sie nun an die Funktionen des Tools: Wie könnten Sie das Tool und dessen Funktionen in den Unterricht integrieren? Bitte beschreiben Sie dazu stichpunktartig 3 Unterrichtsphasen und bewerten Sie diese mithilfe des ICAP-Modells in je einem Satz.

Bitte beschreiben Sie zunächst die erste Unterrichtsphase, in der Coggle eingesetzt wird.

*English: Now please think about the functions of the tool: How could you integrate the tool and its functions into your teaching? Please describe 3 teaching phases in bullet points and evaluate each of them in one sentence using the ICAP model.*

First, please describe the first teaching phase in which Coggle is used.

5. *Task*

German: Bitte beschreiben Sie nun eine zweite Unterrichtsphase, in der Coggle eingesetzt wird.

*English: Now please describe a second teaching phase in which Coggle is used.*

6. *Task*

German: Bitte beschreiben Sie nun eine dritte Unterrichtsphase, in der Coggle eingesetzt wird.

*English: Now please describe a third teaching phase in which Coggle is used.*

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**Data availability** The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval/Consent** All procedures performed in this study were in accordance with the 1964 Helsinki declaration, and the German Psychological Society's (DGPs) ethical guidelines. According to these guidelines, experimental studies only need approval from an institutional review board if participants are exposed to risks that are related to high emotional or physical stress or when participants are not informed about the goals and procedures included in the study. As none of these conditions applied to the current study, we did not seek approval from an institutional review board. Informed consent was obtained from all individual participants included in the study.

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