



Learning with the interactive whiteboard in the classroom: Its impact on vocabulary acquisition, motivation and the role of foreign language anxiety

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Abstract

When used in a sensible way, Interactive Whiteboards (IWB) are supposed to motivate and engage students in learning in the classroom. Thereby, they might also stimulate students who are usually more restrained, such as more anxious students. However, the body of research on the impact of IWB lessons is rather small. The present study investigated whether a 45-minute lesson with the IWB compared to a conceptual identical 45-minute lesson without the IWB would support learning and motivation within the subject English as a foreign language for German students. Moreover, the study examined whether the 45-minute lesson with the IWB compared to the 45-minute lesson without the IWB would be better able to counteract the detrimental effects of foreign language classroom anxiety (FLCA). One hundred and two eighth graders from two secondary schools in Germany took part in this study and were either taught with the IWB (condition IWB; $n=53$) or without the IWB (condition No-IWB; $n=50$). Results showed that students in the IWB condition stated to be higher motivated and performed better in a vocabulary test than their counterparts in the No-IWB condition. FLCA was negatively correlated with performance in the vocabulary test. Other than expected, learning with the IWB did not compensate the detrimental effect of FLCA, meaning that learning with the IWB was more beneficial than learning without the IWB irrespective of a student's FLCA. Implications of the study will be discussed.

Keywords Interactive whiteboard · Foreign language anxiety · Vocabulary acquisition · Motivation · English as a foreign language

1 Introduction

In today's classrooms, digital media use already plays a central role and its importance is growing. One of these digital media that is supposed to possess great potentials in the classroom is the Interactive Whiteboard (IWB). When used properly, lessons with the IWB are supposed to foster students' learning as well as to motivate and engage students (see Shi et al., 2021). Thereby, they might also stimulate students who are usually more restrained, such as more anxious students. However, also due to a lack of (quasi-)experimental studies, we know relatively little about if and for whom, that is for which student characteristics (aptitude-treatment interaction; Cronbach & Snow 1977), learning with the IWB might be especially beneficial. We took up this issue for the current study and examined whether, for the subject English as a foreign language (EFL), the IWB would not only foster learning in general, but would also be able to counteract the negative effects on learning for students with a higher (foreign language) anxiety. Moreover, we also examined whether students' motivation would be increased by the IWB in the classroom, and in turn may explain the potential beneficial effect of learning with the IWB.

1.1 The Impact of Interactive Whiteboards on Motivation and Learning

The IWB is an electronic whiteboard operated via touch-sensitive surface. Interactive whiteboards are a combination of blackboard, computer, overhead projector, CD player, video player or flip chart (Kennwell & Higgins, 2007) and therefore allow the usage of all kinds of media in just one device. Next to integrating several media in one device, the feature of interacting with the IWB is supposed to be one of its major benefits for using it. The IWB allows teachers to integrate games and quizzes easily (as will be also described in the [method](#) section). Depending on the teacher's way to incorporate the IWB in the lesson, students can for instance touch, draw out or move items on the whiteboard, play learning games or present their own work in front of class, thereby taking a more active part in the learning process. As a consequence, the use of the IWB is seen as a method to engage students in the learning process, resulting in improved learning success and motivation.

Concerning the empirical evidence, we will refrain in the following from describing the studies that contribute to the current state of research in detail, since these studies are already summarized and discussed in a recent meta-analysis as well as in a critical review (cf. Kyriakou & Higgins, 2016; Shi et al., 2021). Based upon these latter two research overviews, we will provide the gist of the current state of research. A recent meta-analysis by Shi et al., (2021) showed that using the IWB for teaching (compared to not using the IWB) has a positive impact on learning success (and also a recent study by Aldhafiri (2020) that was not yet included in the meta-analysis showed a positive effect of IWB lessons). Though, the empirical evidence is not that straightforward for at least two reasons: First, the current research situation with respect to the impact of the IWB on learning is still rather sparse, with only a few published (quasi-)experimental studies in this research field (see Mariz et al., 2017; Shi et al., 2021). Second, several studies exist that do not show a beneficial effect on learning success (e.g., Albaaly & Higgins 2012; Shi et al., 2018; for a critical review,

see Kyriakou & Higgins 2016). This calls for further studies that aim at being able to paint a more accurate picture if, when, for whom and how learning with the IWB may be beneficial in the classroom.

One factor, that can at least partly resolve when learning with the IWB is beneficial, is the way the IWB is used in classroom settings (Shi et al., 2021). The IWB does not seem to be very effective when it is solely used as a presentation medium the teacher uses to present all information that students passively receive. However, the IWB is beneficial when interactive features of the IWB are used so that students are actively engaged in learning (see Shi et al., 2021; for similar conclusions see also Aflalo et al., 2018; Swan et al., 2010).

Next to positive effects on learning success, it is also often advocated that lessons with IWBs have a positive effect on students' motivation (Smith et al., 2005). A larger body of studies that used interviews or focus groups as well as several surveys research support this claim (e.g., Mathews-Aydinli & Elaziz 2010; Wall et al., 2005; Wood & Ashfield, 2008; see also Torff & Tirota 2010). Evidence from experimental studies that used a control group design is, once again, rather sparse. Torff and Tirota (2010) investigated over 700 elementary students in mathematics. The authors found a positive effect on motivation. On the other hand, this observed effect was rather small – which also calls for further experimental studies concerning the impact of IWBs on motivation. Thereby, one can also examine whether the (supposed) increase in motivation is responsible for the (supposed) increase in learning success.

Summing up, even though the body of research needs to be substantiated, it is fair to state that IWB's possess high potential to motivate and engage students in learning. This potential might specifically unfold when the interactive features of the whiteboard are used. However, what is rather neglected so far is which students may especially benefit from learning in lessons with the IWB. The current study examined whether students' foreign language classroom anxiety may moderate the effectiveness of learning with the IWB.

1.2 For Whom the IWB may be Especially Beneficial: The Role of Students' Foreign Language Classroom Anxiety

Anxiety is presumably the most often investigated affective variable in foreign language learning research (Teimouri et al., 2019). In this context, anxiety has originally been conceptualized either as a state, as a trait or as a situation specific construct. Over time, only the construct of situation specific language anxiety has proven to be a valid predictor of language acquisition, while this does not account for the more general constructs of state- and trait-anxiety (for a review see MacIntyre & Gardner 1991; Teimouri et al., 2019). The most prominent and widely accepted situation specific anxiety, that is limited to language learning in the classroom, is the construct of foreign language classroom anxiety (FLCA; Horwitz et al., 1986). In their seminal work, Horwitz et al., (1986) conceptualize FLCA as “a distinct complex of self-perceptions, beliefs, feelings, and behaviors related to classroom language learning arising from the uniqueness of the language learning process” (p. 128). Accordingly, students with a higher level of FLCA are supposed to perceive themselves as less competent, to feel uncomfortable and stressed, to be restrained and less engaged and

to avoid getting involved in learning activities in foreign language classroom situations (Aida, 1994; Horwitz et al., 1986; Teimouri et al., 2019; Zhang, 2019). Following, FLCA should negatively affect the motivation to learn as well as negatively affect language acquisition. Indeed, two recent meta-analyses (Teimouri et al., 2019; Zhang, 2019) provide strong empirical evidence for the claim that FLCA is negatively related to performance (e.g., Horwitz 2010; Liu & Huang, 2011), meaning that the more anxious persons are, the worse they perform. The meta-analysis by Zhang (2019) showed a negative correlation of $r = -.36$ between FLCA and performance and similar correlations were observed between other situation specific measures of foreign language anxiety and language acquisition (Teimouri et al., 2019; Zhang, 2019). Overall, these findings of these meta-analyses are quite robust with respect to contextual factors, such as input and target language: The correlations were hardly affected by the target language (which was most often English), or whether input language and target language were from the same language family (e.g., French – English) or from different language families (e.g., Japanese – English).

Next to performance, there is also some evidence that FLCA is negatively correlated with motivation, meaning that the more anxious a person is, the less motivated this person is to learn a foreign language (e.g., Gardner & MacIntyre 1993; Liu & Chen, 2015; Liu & Huang, 2011; Papi, 2010). The magnitude of the observed negative correlation varies between studies, thereby also depending on the assessed motivational questionnaire (e.g., Gardner & MacIntyre 1993; Liu & Chen, 2015). When considering enjoyment, which is in turn closely related to motivation, similar results are obtained: There is a negative relationship of FLCA and enjoyment, with higher levels of anxiety being associated with lower levels of enjoyment (Dewaele & MacIntyre, 2014; Dewaele et al., 2018). All in all, these studies support the claim that foreign language anxiety and motivation are negatively related. Given that motivation to learn is one crucial driving force of learning another language in classroom settings (e.g., Dörnyei 2005; Gardner & MacIntyre, 1993) and that FLCA is negatively related to motivation and language acquisition, there is a need to search for instructional methods that may counteract the impeding effect of FLCA.

One possible way to counteract the negative impact of FLCA may lay in applying instructional methods that try to motivate and engage (also) students with a higher level of FLCA. According to Young (1991), one possibility to motivate and encourage students with higher levels of FLCA to take part in the lesson is to integrate language games and playful approaches. Such an approach may unburden (younger) students from the seriousness of the classroom situation. IWBs possess the potential to integrate playful approaches like games and quizzes easily and thus enable teachers to alternate between phases of learning and playing. Applying the board's potential properly may therefore not only help students in general, but may support students with a higher degree of FLCA to an even higher extent, by counteracting the detrimental effects of FLCA.

1.3 The Present Study: Research Questions and Hypotheses

In the current experimental study, German students (8th graders) were either assigned to an IWB lesson or to a conceptual identical lesson, but without the use of an IWB.

The teacher utilized the interactive features of the IWB in a meaningful way (for more details see method) within the subject English as a foreign language. At the end of the lesson, students took a vocabulary test that addressed new vocabulary that were introduced in the lesson.

The hypotheses are explicated in the following and are also illustrated in the pictorial research frame (Fig. 1). The first research questions addressed the impact of the IWB on performance in the vocabulary test as well as on motivation:

- **Hypothesis 1:** We hypothesized that the IWB lessons would overall lead to better performance than the lesson without the IWB. This is illustrated in Fig. 1 by the path (arrow) from “IWB (vs. No-IWB)” to “Vocabulary Acquisition” and the sign “+”.
- **Hypothesis 2:** Thereby, we assumed that the IWB lessons would be more motivating for students than the lessons without the IWB. This is illustrated in Fig. 1 by the path from “IWB (vs. No-IWB)” to “Motivation” and the sign “+”.

Connected with hypotheses 1 and 2, the current study explored whether the supposed benefit of the IWB lessons on vocabulary learning could be explained by the supposed positive effect of the IWB lessons on motivation:

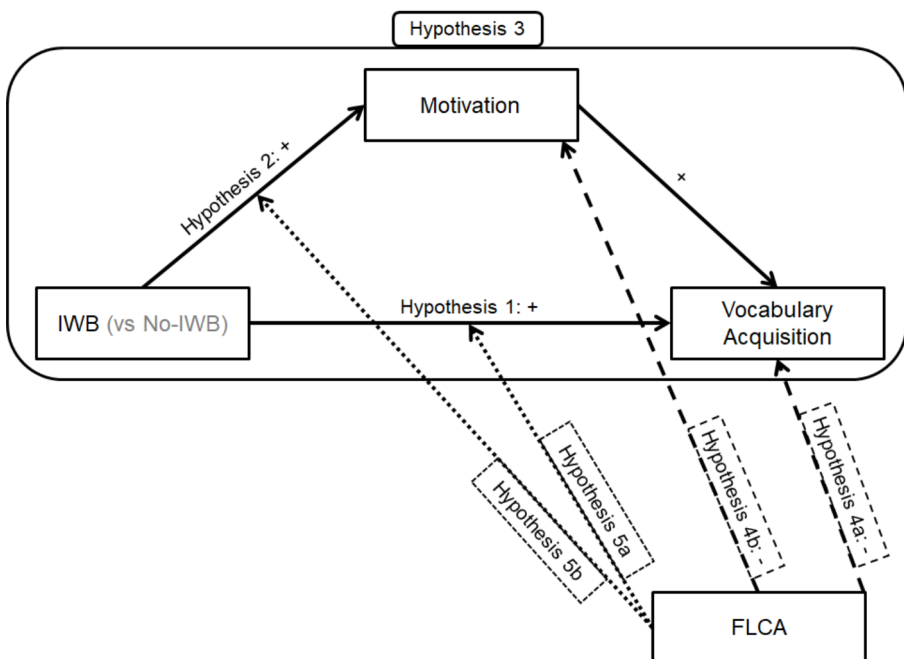


Fig. 1 The pictorial research frame illustrates the hypotheses of this study. It is explicated in more detail at the respective hypotheses in the text

• **Hypothesis 3:** We assumed that motivation would mediate the hypothesized positive effect of IWB lesson on vocabulary learning. This is represented in the upper half of Fig. 1 by the three paths between “IWB (vs. NO-IWB)”, “Motivation” and “Vocabulary Acquisition” (that are framed).

The further research questions addressed the potential influence of FLCA on performance in the vocabulary test as well as on motivation and whether FLCA would have a moderating influence when learning with the IWB compared to learning without the IWB:

• **Hypothesis 4:** We assumed that FLCA would negatively impact performance on the vocabulary test (Hypothesis 4a) as well as negatively impact motivation (Hypothesis 4b). This is illustrated by the respective arrows from “FLCA” to “Vocabulary Acquisition” and “Motivation”, respectively, and the sign “-”.

• **Hypothesis 5:** • The benefits of the IWB lesson compared to a lesson without the IWB should already be evident for students with lower FLCA and even more strongly pronounced for students with a higher degree of FLCA; or in other words: The negative impact of FLCA should be less severe in an IWB lesson compared to a lesson without the IWB. This assumed moderation should be the case for the performance in the vocabulary test (Hypothesis 5a) as well as for students’ motivation (Hypothesis 5b). The assumed moderation of Hypothesis 5a is represented by the arrow from “FLCA” to the path between “IWB (vs. NO-IWB)” and “Vocabulary Acquisition”; Hypothesis 5b is represented by the arrow from “FLCA” to the path between “IWB (vs. NO-IWB)” and “Motivation”.

There is a rather lower amount of experimental studies on the impact of learning with an IWB lesson in the classroom (compared to no IWB lesson), and a lack of research about for whom such lessons may be particularly beneficial. Thus, the current study can be considered as an important contribution in the field, since it aims at widening our knowledge about the generalizability of the positive impact of IWB lessons, as well as for whom IWB lesson may be valuable. Also, the study may clarify, whether an increase in motivation due to the IWB can explain an increase in learning success.

2 Method

2.1 Participants and Design

One hundred and two 8th graders (average age $M=13.7$ years; 63 males, 39 females) from two secondary schools in Germany participated in the study. To be able to take part in this study, students were required to have parental permission (parents had to sign an informed consent, which the students had to hand out to their respective teachers). An ethics approval by means of an ethical board was not mandatory, neither by the University’s guidelines nor by national regulations in Germany. Nevertheless, there are ethical guidelines of the German Psychological Society’s (DGPs;

2004, CIII), which also are in line with the Declaration of Helsinki. The whole conducted study followed the rules set by these ethical guidelines. The design comprised two conditions: Students took either part in one 45-minute lesson that was given with an IWB or students took part in one 45-minute lesson that was conceptually identical, but given without using an IWB (No-IWB). Each 45-minute lesson was the first part of a 90-minute lesson. In the latter part of the 90-minute lesson, a vocabulary test and motivation were assessed. At each school, two classes took part with one class using an IWB and one control class using regular media (overhead projector, CD player and blackboard). The four classes of each school were randomly assigned to one of these two conditions, with $n=53$ in the condition IWB and $n=49$ in the condition No-IWB.

2.2 Instructional Material

The study's lesson consisted of a 45-minutes teaching unit and was given by an educational science student in all four classes. The content consisted of an excerpt of the novel "Down the Rabbit Hole" by Peter Abrahams fitting in the regular curriculum and containing 16 new vocabulary that students had to learn.

In the first phase of the lesson, the students received a picture providing access to the story's topic and activating specific associative fields. Students were asked to describe the picture and to speculate about the story's possible content. In the next step, they received the text in a written form while simultaneously listening to it. After the listening comprehension, students were encouraged to ask for words they did not understand. Depending on condition, two volunteers came either to the IWB or to the overhead projector, respectively, to work out the new words. At the IWB,

Down the rabbit hole

13-year-old Ingrid is a soccer player, an actress AND a big Sherlock Holmes fan. This is important because there has been a murder in Echo Falls. Crazy Katie has been found dead in her house - the evening after Ingrid was there. It was Ingrid's first day of soccer practice; she got lost and Crazy Katie called a taxi for her. That's when Ingrid left her red Puma shoes in the crazy lady's house. Ingrid will have to be as good as Sherlock Holmes to get her red Pumas back and to find the murderer herself because the police are doing it all wrong.

She goes back to Crazy Katie's house at night, climbs through a window and falls into the basement

Flashlight

Ingrid got to her knees. Flashlight. Was it working? Yes. Ingrid shone the light across the room: a room full of newspapers, spiders and dust

She got up and found something horrible in her hair.

She went to the wooden stairs she'd seen on the other side of the room.

Ingrid climbed the dirty old stairs. At the top she came to an open door. Nobody in the house, nothing to be worried about. Night was the same as day, the only difference was the light. And those Pumas: she had to have them.

Ingrid pushed the door open, found herself in the kitchen. She shone the light around: back door, a half-full glass of water on the table, shelf in the corner. There was also chocolate milk! So strange: Katie dead, but her life continued a little longer. She'd probably been looking forward to the chocolate milk.

Fig. 2 Words could be extracted from the text (and is exemplified by the inserted picture of a hand)

the unknown vocabulary was written in separate text boxes and could be extracted by students from the text to look at them in more detail and translate them. To do this, students could touch the respective words and pull them out of the text (see Fig. 2). In the control lessons, the new words were underlined and a translation was written at the texts' margin.

To distract the students from the vocabulary afterwards, a short multiple-choice quiz about the text's details was given. The quiz contained five short sentences, which the students were asked to complete by ticking the correct answer, one out of three possibilities. In both the IWB classes and in the control classes a student was again asked to come to the front to call up classmates and complete the task.

In a next step, to consolidate the newly learned words through repetition, a vocabulary game was played. A game was considered to be the most suitable tool to keep the strain of the learning environment at a low level. Students are supposed to enjoy working with the vocabulary without feeling undue pressure to learn words as fast as possible. In the IWB lesson, the game was made up of three bars in red, green and blue color (see Fig. 3). Each word and its translation were written in a word box. The word above was written in black with its translated equivalent written below in the same green as the bar. At the beginning of the game, all word boxes were in the green field in the middle covered by a green strip. Hence, neither the word nor its translation was visible. Except for the three bars in the background, every item could be moved. By removing the green strips, the upper words were revealed. If the word was touched and slid into either the red or blue bar, the translation became visible, since it was written in green. During the game which was played by the class in two teams (team blue and team red), one word after the other was uncovered by the teacher. The

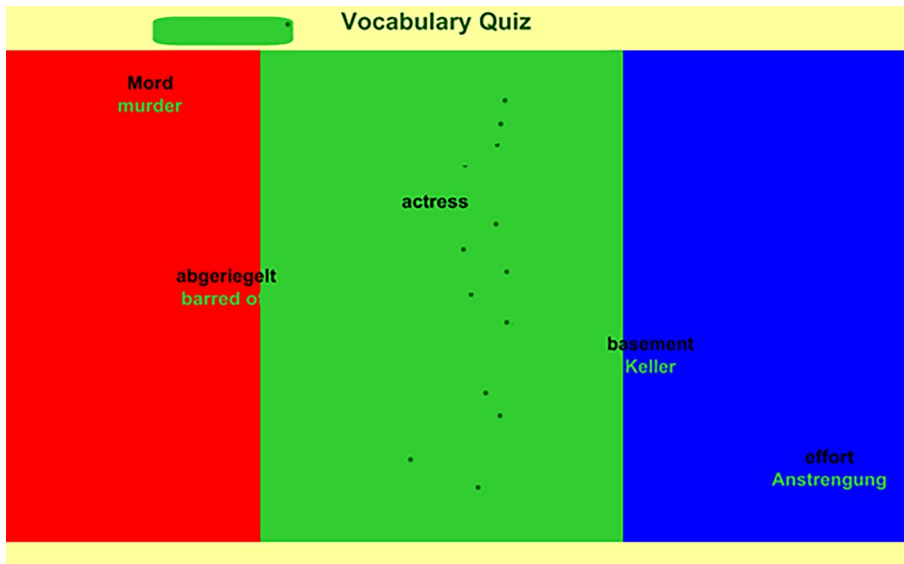


Fig. 3 Snapshot of the vocabulary board from the IWB

student who knew the word first had to stand up and then come to the front to loudly say the translation and then slide the word into the group's color to reveal the answer. If the student's translation was correct, the word stayed in the group's field. If it was wrong, it had to be slid to the opponent bar. The game allowed the students to hear the relevant words pronounced by their fellow students and see them in a written form at the same time.

During the control classes' lessons, a game was played as well. The words were written below each other on a sheet folded in the middle, leaving each word on one side of the paper. The game was played in a similar manner. The fastest student came to the front, pronounced the word and unfolded the paper to check the answer.

2.3 Measures

A prior knowledge test served as control variable and a FLCA test served as control variable and moderator variable. A vocabulary test and a motivational questionnaire were assessed as dependent variables. Furthermore, an evaluative questionnaire was assessed.

2.3.1 Foreign Language Classroom Anxiety

To test the role of foreign language classroom anxiety when learning new words in an English lesson, a translated version of the Foreign Language Classroom Anxiety Scale (FLCAS; Horwitz et al., 1986) was used. It consists of 33 items inquiring about students' confidence or anxiety regarding English classes. They were asked whether they feel insecure or confident when taking part in different classroom situations during an English lesson (e.g., "In language class, I can get so nervous I forget things I know." or "I feel confident when I speak in foreign language class"). The items had to be rated on a 5-point-Likert scale with the labels (1) 'strongly agree', (2) 'agree', (3) 'neutral', (4) 'disagree' and (5) 'strongly disagree'. Twenty-three of the 33 items were negatively formulated and were recoded for scoring. The total score was calculated by the arithmetic mean of the 33 items, meaning that the higher the total score, the higher the self-reported foreign language classroom anxiety. The internal consistency of the scale was very good ($\alpha=.93$). Note that students sometimes crossed their answer between two values, for instance between the value of 3 and 4. In such cases the value between these two numbers was used (in this example the value 3.5 would be given for the answer). Also note that in 13 out of 3336 cases (33 items x 102 students), students missed to fill out an item – this was accounted for by using the arithmetic mean.

2.3.2 Prior Knowledge Test of Vocabulary

The prior knowledge test consisted of six English terms the students were asked to translate into German. These six words were taught in the study's lesson and were part of the vocabulary test as well. For each correctly translated term, students received one point and the points were summed up to an overall prior knowledge score (and transformed into percentage).

2.3.3 Vocabulary Test

Learning outcomes were measured by a vocabulary test asking the students to reproduce all 16 learnt words. Some of the 16 words were given in English and students were asked to translate them into German and the remaining words were given in German and students were asked to translate them into English. Students received one point for each correctly translated term. The points were summed up to an overall vocabulary test score (and transformed into percentage).

2.3.4 Evaluative and Motivational Questionnaire

In this questionnaire, students were first asked to fill out demographic data as well as to indicate how often they would use the IWB at school (a) 0 h per week, b) 1–4 h per week, c) 5–10 h per week, d) more than 10 h per week). The subsequent questionnaire consisted of 38 items in total that had to be rated on a 5-point-Likert scale ranging from (5) ‘strongly agree’ to (1) ‘strongly disagree’. The used questionnaire can be distinguished in several parts asking about (a) the attitude towards IWBs (14 items), (b) the attitude towards school in general (5 items), (c) how commonly the IWB is used in different school subjects (7 items), (d) for which of predefined purposes the IWB is generally used (5 items), and (e) how motivating the current lesson was (7 items). Parts (a) and (b) were based on a modified and translated version of the Computer Attitude Questionnaire (CAQ; Knezek & Christensen 1996). Parts (c) and (d) were added to investigate whether the students are already used to working with IWBs and how their teachers use them normally. Parts (a) to (d) will not further be explored in this article, since they mainly served evaluative purposes. Part (e) was assessed to find out if the students taught with the IWB were more motivated by their lesson than their fellow students in the control class. The motivational scale of this questionnaire consisted of seven items (e.g., “Did you find today’s lesson interesting?” or “Did you enjoy learning vocabulary?”). The total score for motivation was calculated by the arithmetic mean of the seven items with a higher total score meaning a higher motivation. The motivational scale showed a high internal consistency ($\alpha = .89$). Occasionally, students crossed the scale between two numbers, for instance between 3 and 4. In such cases the value between these two numbers was used (in this example the value 3.5 would be given for the answer). Overall, this was the case for 23 answers out of 714 (7 items x 102 students).

2.4 Procedure

Informed consent was obtained from the parents. The learning environment comprised of a short introduction providing the 8th graders with some information about the study they were participating in. Before the lesson started, they were asked to fill in the FLCAS followed by the prior knowledge test of vocabulary. Thereafter, the study’s lesson started, depending on experimental conditions either with or without interactive whiteboards. The educational science student who taught these lessons (and who is a co-author of this manuscript) was instructed to behave motivationally identical in all classes. After 45 min, when the lesson was over, the class was dis-

tracted for 30 min by their regular English teacher and miscellaneous organizational topics were discussed at that time. After this distraction phase, the vocabulary test was given. The students had 10 min to fill in the 16 newly learned words from the study's lesson. Finally, students were asked to fill in the evaluative and motivational questionnaires. Having finished the lessons, the teaching person wrote a protocol about the impression concerning the given lessons.

3 Results

The means and standard deviations for the two groups are reported in Table 1.

3.1 Control Variables

Firstly, it was examined whether the students of the two treatment groups could be considered equal with respect to the variables assessed prior to experimental manipulation, namely to prior knowledge and FLCA. At this, separate *t*-tests for independent means were conducted. There were no differences between students in the IWB and No-IWB conditions for prior knowledge, $t(100) = -1.00$, $p = .32$ or for FLCA $t(100) = -0.08$, $p = .94$. Hence, the conditions could be regarded as equal with respect to these assessed prerequisites.

3.2 The Influence of IWBs on Performance in the Vocabulary Test and Motivation

Secondly, it was analyzed if learners in the IWB and No-IWB conditions differed concerning the dependent variables learning outcome and motivation. In line with Hypothesis 1, *t*-tests for independent means revealed significant differences for performance in the vocabulary test, $t(100) = 2.58$, $p = .01$, $d = 0.51$, with students in the IWB condition achieving higher scores than students in the No-IWB condition. In line with Hypothesis 2, *t*-tests for independent means also revealed significant differences for motivation, $t(100) = 4.60$, $p < .001$, $d = 0.91$, with students in the IWB condition stating to be higher motivated than students in the No-IWB condition. There was a significant relationship between motivation and performance in the vocabulary test ($r = .22$, $p = .03$), with a higher motivation being associated with higher performance.

Table 1 Means (and SD) for prior knowledge of vocabulary, foreign language classroom anxiety, performance in vocabulary test and motivation

	IWB ($n=53$)	No IWB ($n=49$)
Prior knowledge of vocabulary (in %)	37.11 (19.51)	37.42 (19.10)
FLCAS	2.16 (0.53)	2.27 (0.57)
Performance in vocabulary test (in %)	85.73 (12.54)	78.19 (16.79)
Motivation	4.44 (0.54)	3.88 (0.67)

3.3 Can Motivation Explain the Differences in Performance Between the IWB and No-IWB Conditions?

Teaching with the IWB had an influence on students' performance in the vocabulary test as well as on their motivation. Moreover, these two dependent variables correlated significantly. Hence, the premises were given to conduct a mediation analysis with learning conditions (IWB vs. No-IWB) as independent variable, motivation as mediator and performance in the vocabulary test as dependent variable. To execute the mediation analysis, the tool PROCESS for SPSS (Version 3.5.3) was used (Hayes, 2017) with 5.000 bootstrap samples. However, the indirect effect was not significant, $b = -0.27$, $SE B = 0.21$, 95% CI [-0.67, 0.19]. These results mean that the assessed motivation of students could not explain the positive effect of the IWB lessons on performance in the vocabulary test and are not in line with Hypothesis 3.

3.4 How does FLCA Influence Learning with the IWB?

Thirdly, it was examined whether FLCA would moderate learning with IWBs compared to the No-IWBs for performance in the vocabulary test as well as for motivation. For executing the moderation analyses, the tool PROCESS for SPSS (Version 3.5.3) was applied (Hayes, 2017) and all variables that define products were mean centered and 5000 bootstrap samples were used. For the dependent variable performance in the vocabulary test, results showed a main effect for condition, $b = -1.02$, 95% CI [-1.88, -0.16], $SE B = 0.43$, $p = .02$, (which basically reflects the observed differences derived for the t-test described above). Results also showed a main effect of FLCA, $b = -1.71$, 95% CI [-2.49, -0.92], $SE B = 0.40$, $p < .001$, meaning that FLCA had a negative impact on performance in the vocabulary test, which is in line with Hypothesis 4a (the corresponding correlation between FLCA and performance in the vocabulary test is $r = -.41$, $p < .001$). However, other than expected in Hypothesis 5a, FLCA did not moderate learning with the IWB, $b = -0.23$, 95% CI [-1.80, 1.34], $SE B = 0.79$, $p = .77$.

For the dependent variable motivation, results showed a main effect for condition, $b = -0.53$, 95% CI [-0.77, -0.30], $SE B = 0.12$, $p = .02$, (which basically reflects the observed differences derived for the t-test described above). Results showed only a marginal effect of FLCA, $b = -0.20$, 95% CI [-0.41, 0.02], $SE B = 0.11$, $p = .08$, meaning that FLCA had only a marginal negative impact on motivation (the corresponding correlation between FLCA and motivation is $r = -.19$, $p = .05$). Considering Hypothesis 5b, other than expected, FLCA did not moderate learning with the IWB for the dependent variable motivation, $b = 0.27$, 95% CI [-0.016, 0.70], $SE B = 0.22$, $p = .22$.

4 Summary and Discussion

The use of digital media in the classroom, such as the IWB, is becoming more and more important. By this study, we aimed at getting a clearer picture about if, and for whom, IWB lessons may be beneficial by researching how IWB lessons (compared to lessons without IWB) and students' FLCA affected learning in the classroom. We

investigated whether an IWB lesson can foster the acquisition of vocabulary and increase motivation. Moreover, we examined the role of students' FLCA when learning in an IWB lesson compared to a lesson without IWB on performance in a vocabulary test as well as motivation.

4.1 The Impact of IWB on Learning and Motivation

In accordance with our first hypothesis, IWB lessons led to a better performance in a vocabulary test than lessons without the IWB. Thereby, we observed a medium effect size ($d=0.51$), which can be considered as educational meaningful (Hattie, 2008). These results on performance are consistent with a recent meta-analysis (Shi et al., 2021). Moreover, this study is one of on the few experimental studies in which the impact of IWB (vs. no IWB) lessons on motivation was investigated (Torff & Tirotta, 2010). In line with our second hypothesis, the IWB lessons motivated students more strongly to take part in the lesson, as indicated by the scores of the motivational questionnaire, than lesson without the IWB. The lessons without the IWB were supposed to resemble the IWB lessons. We can report anecdotally that for the IWB lessons, the transitions between phases were more fluent than in the no IWB lessons, where a change of media had to be implemented several times to resemble the IWB lesson (e.g., from the overhead projector to the black board to the CD player etc.). With the IWB on the other hand, these transitions were smoother since all devices are integrated in the IWB. The better flow within the IWB lesson might have contributed to a higher motivation of students.

Contrary to Hypothesis 3, however, the non-significant effect of the mediation analysis revealed that the observed boost in motivation in the IWB lesson cannot explain the beneficial effect of the IWB lessons on performance in the vocabulary test. Two potential reasons might explain this unexpected finding: First, it needs to be clarified that presumably not motivation per se will lead to better learning, but that motivation will lead to a deeper engagement with the contents, which in turn will lead to better performance (see the Cognitive-Affective Theory of Learning with Media, Moreno & Mayer 2007). It may thus be the case that the IWB, next to motivation, will additionally stimulate valuable cognitive processes and cognitive engagement. However, as we unfortunately did not measure cognitive engagement in this study (neither with a questionnaire, nor did we protocol the proportion of students who participated actively in the lesson), we are hence not able to clarify this issue. Assessing these variables in future studies may provide deeper insights and a better understanding of what causes the beneficial effect of IWB lessons and may be a fruitful avenue. Second, even though the assessed motivation questionnaire showed a good internal consistency and was sensitive to detect differences between conditions, it may be that the way we assessed motivation was not ideal. On the one hand, the used questionnaire is not an established motivational questionnaire; thus, there may be questionnaires that are even more suited to determine the motivational effects of IWB lessons. On the other hand, the motivational questionnaire was assessed after the vocabulary test; hence, students' perceived performance in the vocabulary test might have affected their responses in the motivational questionnaire. This rather small limitation may be resolved in future studies.

4.2 The Role of FLCA

In accordance with Hypothesis 4a, the FLCAS was negatively associated with performance in a vocabulary test. Thereby, the observed magnitude of the correlation ($r = -.41$) closely matches with the correlation observed in a recent meta-analysis on this topic, where a correlation of $r = -.36$ was observed for the FLCAS and performance (Zhang, 2019). It should be noted though that German students are rarely investigated in the context of studies using the FLCAS and that the current study thereby also contributes to substantiating the relationship between FLCA and performance. The hypothesized negative association of the FLCAS with motivation (Hypothesis 4b) was only marginal. Generally, the magnitude of the negative correlation between the FLCAS and motivation is also dependent of the used motivational questionnaire (Liu & Chen, 2015). The somewhat lower negative correlation in this study may be attributed to the applied motivational questionnaire. For future studies, more established motivational questionnaires may be administered. Finally, the present study also investigated whether FLCA would moderate learning with the different learning conditions (IWB vs. no IWB). Thereby, it was hypothesized that the negative impact of FLCA on vocabulary acquisition (Hypothesis 5a) and motivation (Hypothesis 5b) should be less severe when students are taught in an IWB lesson compared to a lesson without IWB. However, other than assumed, FLCA did not moderate learning with the IWB, meaning that the negative impact of FLCA on performance and motivation was comparable for students who were taught with the IWB and students who were taught without the IWB.

What could have caused this missing moderating effect of FLCA on learning with the IWB? First, it may simply be the case that an IWB lesson that tries to exploit the interactive features of the IWB and to motivate and engage all students does not target and affect students with higher FLCA to a higher extent, meaning that the original idea would have to be rejected. This does however not mean that joyful lessons and playful approaches may generally be unsuited (cf. Young, 1991), since in the present study a playful approach was also realized in the classes without IWB. Second, the missing moderating effect of FLCA may also be attributed to the population of this study. Overall, FLCA was fortunately comparatively low in the assessed students, with an arithmetic mean around 2.21 (with a theoretical minimum of 1 and a maximum of 5). Thus, it may be the case that when a population would be used that is more anxious about foreign language learning, the assumed moderating effect of FLCA in IWB lessons may be observable. Clearly, this notion is speculative, but may be investigated in future studies. A more anxious population may be more reliably found with higher ages (Er, 2015), such as university students (e.g., Aida 1994).

4.3 Limitations and Outlook

This is one of few studies where the duration of the study did not comprise a longer period of time, but comprised only one lesson (also Lin et al., 2014; see also Shi et al., 2021). Even for this short period of time, a positive effect of the IWB on learning success and motivation showed up. This implies that the IWB does not need to be used permanently to be beneficial, but could also be used sporadically, whenever it

suits the teacher and the topic. One may argue that the positive found effect of using the IWB, particularly for such a short period of time, is mainly a novelty effect (cf. Clark, 1983). However, we want to reject this notion since students who took part in this study seemed to be well informed and familiar with the IWB. Moreover, a recent meta-analysis (Shi et al., 2021) found that the positive effect of the IWB is independent of the period of time in which the IWB was used, meaning that the positive effect of the IWB did not decrease over time. This also speaks against the notion that found positive effects when using the IWB can mainly be traced back to a novelty effect, since a novelty effect would decrease over time. We figure that the short period of time in the current study and its found effect is valid and can contribute to the rather low body of research. Nevertheless, we do not want to overinterpret the results, but think that further research is necessary to substantiate the findings.

The relation between FLCA and IWB lessons was investigated for the duration of one lesson and it was examined whether the IWB would benefit learners with higher FLCA. It may be the case that such potentially beneficial effects of the IWB for learners with higher FLCA may not shine through in one lesson, but come first observable in the longer run, thereby potentially even reducing FLCA. Even though this notion is speculative, it may nevertheless be worthwhile to investigate the possibility that the motivating character of the IWB supports students with higher FLCA. Given the detrimental effect of FLCA, it would be desirable for teachers to have comparatively simple instructional methods available that help them in supporting and motivating more anxious students.

4.4 Conclusions

The current study contributed to the rather low body of research about the impact of IWB lessons on learning and motivation. The study showed that an IWB lesson, where the teachers apply the IWB by using the interactive features in a meaningful way, can motivate students and support their learning (see also Shi et al., 2021). Thereby, and as shown in this study, the IWB does not necessarily need to be used frequently to show its positive effects. Thus, we want to advocate for and encourage teachers to incorporate teaching with the IWB in their method portfolio. Whether using the IWB more often will especially support more anxious students, that are usually rather restrained in the classroom, may be a fruitful avenue for further research.

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Data The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Statements and Declarations

Competing interests The authors have no relevant financial or non-financial interests to disclose.

Ethics approval This study was performed in line with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. An ethics approval by means of an ethical board was not mandatory, neither by the University's guidelines nor by national regulations in Germany. Nevertheless, there are ethical guidelines of the German Psychological Society's (DGPs; 2004, CIII) and the whole conducted study followed the rules set by these ethical guidelines.

Informed consent Informed consent was obtained from the parents.

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