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From Research to Retweets—Exploring the Role of Educational Twitter (X) Communities in Promoting Science Communication and Evidence-Based Teaching

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Abstract: Twitter has evolved from its initial purpose as a microblogging social network to a pivotal platform for science communication. Equally, it has gained significant popularity among teachers who utilize communities like the German #twitterlehrerzimmer (TWLZ; Twitter teachers' lounge) as a digital professional learning network. (1) Background: To date, no studies examine how science communication is conducted on Twitter specifically tailored to teachers' needs and whether this facilitates evidence-based teaching. (2) Methods: Answering the three research questions involved a comprehensive mixed methods approach comprising an online teacher survey, utility analysis using Analytical Hierarchy Process (AHP) models, and machine learning-assisted tweet analyses. (3) Results: Teachers implement research findings from the TWLZ in their teaching about twice a month. They prefer interactive tweets with specific content-related, communicative, and interactive tweet features. Science communication in the TWLZ differs from everyday communication but notably emphasizes the relevance of transfer events for educational practice. (4) Conclusions: Findings highlight that dialogue is essential for successful science communication. Practical implications arise from new guidelines on how research findings should be communicated and encourage teachers to reflect on their Twitter usage and attitude toward evidence-based teaching. Recommendations for further research in this emerging field are also discussed.

Keywords: social media; twitter (X); teacher professional development; science communication; researcher–practitioner gap; evidence-based teaching; teacher survey; analytical hierarchy process; natural language processing; sentiment analysis

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1. Introduction

The microblogging service Twitter, prior to the changes to X, has been a popular platform for people to exchange knowledge and engage in discourse. The term "Twitter" is used in the following, as during the data collection period, the social network was known by that name and the analysis is based on its functionalities at that time, rather than the limited functionality of X. Twitter has gained significant popularity as a platform for science communication. Much research exists on how scientists or universities utilize Twitter to disseminate their research findings [1–4] and engage with audiences [5–7]. Simultaneously, Twitter has also become a prevalent platform among teachers. Several studies have analyzed professional learning and development networks on Twitter within educational contexts [8–12] in Germany [13–15].

However, an unexplored intersection remains at the juncture of these two domains: science communication with teachers on Twitter. This unaddressed research gap underscores the need for further investigation to understand if and how science communication on Twitter with teachers works. It is crucial to examine how this type of science commu-

nication on Twitter could create opportunities for promoting the frequently demanded practices of evidence-based teaching [16–20].

The aim of this study is to bridge this research gap by investigating the communication of scientific research findings within the German teacher sphere on Twitter. For this purpose, we examine the teacher community behind the German hashtag #twitterlehrerzimmer or short #TWLZ, which can be translated as "Twitter teachers' lounge". The study uses a comprehensive mixed methods approach to determine whether teachers implement scientific evidence from Twitter in their teaching, explore their preferences concerning science communication, and conduct further tweet analysis to characterize the (science-based) communication. This study contributes significant implications for both educational research and practice due to its innovative combination of teacher surveys, Analytic Hierarchy Process inquiries, and in-depth tweet analyses. It provides insights for enhancing the effective communication of scientific knowledge for teachers on Twitter and encourages this target group to reflect on their own Twitter usage and attitudes toward evidence-based teaching.

1.1. Needs for Evidence-Based Teaching

"Evidence-based teaching" refers to an educational approach that involves making instructional decisions and designing teaching methods based on carefully analyzing and integrating empirical evidence, research findings, and proven best practices [21]. This approach emphasizes using reliable and valid data to inform teaching strategies, curriculum design, and classroom interventions to improve student learning outcomes and educational effectiveness. Current educational policies and the growing demand for evidence-based teaching significantly impact teaching practices [18,22]. According to the "Standards for Teacher Education" established by the German Standing Conference of the Ministers of Education and Cultural Affairs (Kultusministerkonferenz), the ability to review, evaluate, and integrate research findings into one's own teaching is defined as a central goal of teacher training [16].

Therefore, it is crucial to establish a theoretical framework for evidence-based teaching from the perspective of teachers. In contrast to numerous frameworks centered on student outcomes, this study aims to emphasize the teacher's perspective in evidence-based teaching, recognizing the influence of specific normative and theoretical constructs on how teachers utilize research findings. Certain relationships between theories and habitus either hinder or enable research findings to become a source of knowledge for teachers in their evidence-based teaching [23]. Evidence-based teaching requires teachers to read and comprehend scientific literature and derive implications for their professional teaching practices. Teachers are generally interested in implementing research findings into their teaching practices [24]. Regarding teachers' use of evidence-based practices, there are various theoretical approaches [17,25], categorized by the type of evidence and its integration into teachers' action cycles [26]. For the variables analyzed in our study, we focus primarily on evidence-based products and theories in informed decision making. Before engaging in evidence-based teaching, teachers seek long-term collaborations with universities in science-practice partnerships [17] to engage in dialogue. Twitter serves as a space where teachers can contribute to educational reforms, fostering a unique dialogue involving various stakeholders and contributing to dynamic political processes and decision making [27]. Educational reforms have fostered high-quality discussions among teachers, researchers, and administrators [28], which can likely be translated into science communication and evidence-based teaching. Reducing the research–practitioner gap can promote that empirical evidence reaches educational practice and that teaching and learning can be optimized [20], thereby facilitating evidence-based teaching.

However, there are often hurdles in evidence-based teaching, such as access to research, time limitations, or lack of institutional support [24]. Reading and understanding scientific studies also pose significant challenges for teachers [29]. Second-order meta-analyses such as Hattie's [30] aim to provide an overview of a broad research field, but research

syntheses on their own are often still too extensive and complex and are rejected by teachers if they do not align with their experiences [19]. Therefore, Twitter offers an exciting alternative to communicate research findings with and for teachers, given the need to limit communication within a few characters and format templates. This is where this study connects, aiming to provide guidance to researchers on making their results more attractive based on the analyses and interests of teachers. In order to meet teachers' needs for information on evidence-based teaching, educational research needs to focus more on science communication and how this can promote evidence-based teaching [18].

1.2. Science Communication on Twitter

Science communication, in general, plays an essential role in bridging the gap between academic research and practical application. It is a vital channel for conveying scientific findings, making them accessible, understandable, and applicable to various audiences, including teachers. Science communication by educational institutes or researchers for teachers and school staff refers to the "use of appropriate skills, media, activities, and dialogue to produce one or more of the following personal responses: awareness, enjoyment, interest, opinions or understanding of science" [31] (p. 191). This exchange endeavors to bridge the gap between research and practical application in education, promoting evidence-based teaching methods. One platform for this exchange is Twitter, making it essential to examine the actors in educational communication and the quality criteria for scientific tweets. This focus allows an assessment of the effectiveness of this (science-based) communication and the identification of processes to make scientific insights on Twitter more accessible and useful for teachers.

There is a significant need to consider scientific communication beyond traditional publication-based dissemination, particularly within the dynamic realm of social networks such as Twitter [32]. In disciplines like Humanities and Social Sciences, researchers use Twitter extensively to disseminate their research results [1,2]. This practice offers numerous benefits to researchers, with tweets about their research often correlating with increased citations [3,4]. Additionally, practitioners benefit from this approach, as the shared research findings are encountered and disseminated by many non-academic professionals [2]. Existing research reveals that scholars in the Humanities mainly tweet about scientific content but exhibit limited tweet engagement [7]. Dialogical communication structures appear to be of significant importance in this regard, evident in university science communication. University Twitter feeds target a broad audience but rarely utilize dialogic loop features [5,6]. Although research universities are notably active on Twitter, teacher education institutions are the least active [6]. Therefore, it is crucial to consider both the activity in educational research and educational practice to bridge the gap between theory and practice and to promote knowledge transfer [20]. To best address this gap, additional pathways of disseminating and communicating research findings through automated Twitter bots need to be explored.

Twitter bots refer to software that manages Twitter accounts. There are various types of bots, including chat bots, gaming bots, and social bots, characterized as partially or fully automated user accounts on social media platforms [33]. These social bots have been particularly significant on Twitter because they are software that are capable of autonomously performing actions and interactions on the platform. Among these autonomous actions is the automated posting and retweeting of educational research findings for teachers in the TWLZ. Generally, bots significantly influence Twitter activity, although they represent a relatively small percentage of users; they have a much larger impact on tweet clicks than real users [34]. With the transition from Twitter to X, some bots designed to artificially boost the emergence of political or societal initiatives (e.g., astroturfing-bots) decreased in number, while other types of bots continued to proliferate on X [35]. Within educational communities on Twitter, there is a shift from original tweets toward retweets, although previous analyses have often disregarded the retweet activities of bots entirely [10]. While there is existing research on bots, news sharing, and trustworthiness in disseminating

health research findings, there remains a substantial gap regarding communicated research findings in education on Twitter, which this endeavor aims to address [36,37]. This contribution aims to close this gap and enhance communication by making it mutually engaging, based on tweet quality criteria.

Tweets possess specific content-related, communicative, and interactive quality traits that can enhance the likelihood of retweets based on the Twitter algorithm. Qualitative, quantitative, or mixed methods approaches can be used to analyze tweet components. Generally, tweets are notably engaging when their content is interesting. Research findings highlight that information sharing, self-promotion, and questions to followers are particularly popular content types [38]. These contents can also be applied to tweets within the TWLZ, such as information sharing from educational researchers, self-promotion from commercial digital teaching tools, and, finally, queries addressing experiences to followers or fellow teachers within the TWLZ.

To appropriately characterize (science-based) communication and teacher communities in the TWLZ, specific communicative tweet features need to be considered. Communicatively, the use of hashtags and mentions is crucial. Using a few targeted hashtags (<10) makes a tweet more successful and should be integrated into the text rather than at the end of the tweet [39]. Additionally, how a tweet is communicated plays a significant role. Sentiment analysis of tweets demonstrates that positive tweets are more effective and that negative tones should be avoided [38,39]. Sophisticated language models are now deployed to automatically assess sentiments in the German-speaking Twitter space [40]. These analyses are necessary to determine if tweets with specific sentiments, for instance, are better received by teachers and lead to increased tweet engagements, providing crucial recommendations for science communication and promoting evidence-based teaching.

Equally important is illustrating the tweet content through multimedia. There are correlations between engagement and content-related indicators and functional indicators like multimedia content [7]. Studies also indicate that research results from large institutions spread more rapidly on Twitter when they include links and multimedia content, such as a photo [41]. The aforementioned linked content serves as a critical interactive tweet feature. Tweets are more effective when a few particularly influential accounts (eight or fewer) are mentioned [39]. The more followers an account has, the more engagement is expected in the tweets [1]. Account properties of users, like Twitter verification, are also interesting to distinguish the Twitter activity of verified researchers and institutions from that of teachers on Twitter [42]. Additionally, other traits such as posting time should be collected to further characterize communication [39]. All these interactive tweet features are significant in capturing teachers' preferences concerning (science-based) communication in the TWLZ. Features such as verification status or optimal tweet timing yield essential implications for scientists and research institutes, aiding in enhancing their communication strategies for disseminating research findings to educators within educational Twitter communities like the TWLZ.

1.3. Teachers' Twitter-Based Professional Learning Network

As mentioned, Twitter is highly popular among researchers, but it is also widely utilized by teachers. They use Twitter not only to access the latest research findings but also as a digital professional learning network.

In 2009, teachers began engaging in the English-speaking Twitter sphere under the hashtag #edchat [8], which later evolved into a weekly Twitter chat in the German-speaking region under #EDchatDE. This eventually led to the development of the asynchronous exchange platform known as the #twitterlehrerzimmer or short #twlz, which constitutes an important community where teachers can exchange ideas and further develop their skills. Online communities like these bring together individuals with similar interests. A recent systematic review showed that online communities among teachers offer an important resource for cultivating supportive and collaborative professional approaches [43]. By utilizing memorable hashtags, teachers organize themselves in affinity spaces [11,44]. When

teachers seek out and share various practical recommendations, it signifies a community of practice. In the TWLZ, such a community exists; for instance, more active teachers often share their teaching experiences, while less active teachers directly seek instructional materials [45], thereby enabling individuals to obtain tailor-made information. Research findings in biology education, for example, demonstrate that Twitter provides a supportive environment for highly qualitative professional development, tailored to individual needs [46]. Twitter serves as an additional and suitable platform for professional development as it allows the assembly of learning content aligned with individual interests and experiences, unlike traditional training sessions in schools or institutes [9]. The digital professional development of teachers on Twitter involves utilizing the platform for continual learning, resource sharing, and active participation in educational discussions to enhance teaching abilities and knowledge. In addition to these advantages, it should be noted that extreme forms of disapproval or harsh commentary can occur in those networks [46], and that (professional) learning on social media is not subject to any form of quality control [47]. Twitter serves as a space where teachers engage in continuous learning and keep abreast of educational trends [12]. The results of a meta-analysis show that teachers primarily use Twitter in educational settings as a tool for information acquisition, exchanging ideas, participating in a community, and sharing insights on specific subjects [48]. Specifically concerning the activities of social science teachers, they use Twitter for chats, backchanneling emotional support, communication with students and parents, and in- or out-of-class activities in addition to the aforementioned purposes [49]. A mixed methods examination of the content retweeted by the TWLZ Bot during the COVID-19 pandemic demonstrates that teachers primarily utilized the TWLZ as a digital professional learning network to exchange information about effective digital teaching, materials, and hygiene standards in schools [14]. Here, this study aims to conduct further mixed methods assessments encompassing teachers from all disciplines, not solely focused on digital teaching practices during the pandemic.

Within the scope of professional development networks, teachers in the TWLZ aim to broaden their knowledge and improve their skills [46,50]. Notably, the sources of knowledge for teachers' methodological and didactical instructional decisions are crucial. These sources or resources can take various forms, encompassing experience-based knowledge and subjective or scientific theories. Previous studies indicate that teachers' pedagogical decisions often rely on subjective theories and experiential knowledge rather than scientific theories and research findings [51–53]. However, the latter two are additionally very important for evidence-based teaching and thus are a vital component of this study. Through digital professional development in the TWLZ, teachers undergo changes in their thinking, behavior, and relationships in teaching, research, and collaboration [54]. It also helps them shape an identity as both teachers and researchers [55], as well as self-proclaimed education experts or influencers [10,56]. Given these distinct personal characteristics, especially among teachers as researchers, it is assumed that they generally exhibit a positive attitude toward evidence-based teaching. The aim is to investigate the use of and attitude toward evidence-based teaching, as there are currently no comparative data regarding the teachers' disposition toward transferring research outcomes from the TWLZ into practice.

1.4. The Present Study

This study aims to investigate the role of educational Twitter communities in promoting science communication and evidence-based teaching. The study recognizes Twitter's diverse user base; however, it specifically focuses on actors within the TWLZ, including teachers, researchers, and the general public interested in education-related topics.

To address these relationships and the previously described research gap, this study will employ a comprehensive mixed methods approach. The study will focus on three central research questions and corresponding methods:

1. Do teachers utilize scientific evidence from the Twitter teachers' lounge in their classroom teaching and school practices?

2. What should science communication on Twitter look like for and by teachers?
3. How can we characterize (science-based) actual communication within the Twitter teachers' lounge?

These questions will be addressed through a teacher survey, Analytic Hierarchy Process (AHP) decision-making technique, and in-depth tweet analyses. As a result, they will contribute to improving effective communication and collaboration among researchers, teachers, and other stakeholders on Twitter, further promoting evidence-based teaching.

2. Materials and Methods

This section outlines the step-by-step methodology employed in this research. To enhance the clarity of the research methodology, the sample of teachers and tweets is first described, followed by a description of individual methods and materials, structured according to the research questions.

2.1. Sample Description

The teacher sample of the survey exclusively includes teachers who were active in the TWLZ between February and September 2022. Reasons for this timeframe are detailed below along with the corresponding period for the tweet sample. Active teachers were recruited in two ways. First, based on a network analysis from Luca Hammer [57], the largest or most influential teachers in the TWLZ were contacted and were identified as active based on the tweet sample. Other teachers who were deemed "active" based on the tweet sample were also contacted. In this context, "active" refers to the identification of Twitter users in the tweet analysis who posted content with the hashtag #twitterlehrerzimmer or similar particularly frequently during the mentioned period. They were proactively approached on Twitter and invited to participate in the survey. This approach resulted in a total of 121 teachers being contacted. Second, in addition to the proactive recruitment, two tweets were used to promote the survey on Twitter, allowing teachers to participate voluntarily. The TWLZ activity of the survey participants was not cross-referenced with the tweet sample but was queried through self-disclosure at the beginning of the survey.

The data collection period for the online survey, conducted via SoSci Survey [58], was from 16 August 2023 to 4 September 2023, totaling 20 days. During this period, the survey link was clicked 250 times, resulting in 41 valid cases, of which 27 individuals completed the survey in full (reached the last page). To address the first research question, all 41 teacher surveys were included, but for specific variables, cases with missing values were excluded using pairwise deletion. The number of included cases can be found in the descriptive data summaries in the results. For addressing the second research question, 26 out of the 27 teacher surveys were included. One case had to be excluded as the expert status of the person could not be clearly determined due to an unanswered filter question. Of the included cases, 19.23% (5 out of 26) of the teachers were classified as activity or expert level three out of four (active in the TWLZ once or twice a week). For further analysis using the AHP, it is important to verify the activity or resulting expert status of the survey participants. The small percentage of slightly less active experts at level three was nevertheless included in the AHP analyses because the results of the weights and confidence intervals of the pairwise comparison matrix with and without expert level three did not significantly differ in the first two cases and the last two cases ($t(10) = 0.040$, $p = 0.97$).

The tweet sample is crucial for answering the third research question and is based on retweeted posts from a bot within the TWLZ. The bot (@Bot_TwLehrerZ) automatically reposted tweets with the hashtags #twitterlehrerzimmer, #twlz, and #twitterlz from August 2019 to July 2023, making it a central hub for teachers on Twitter. This bot is very active, having retweeted 379,924 tweets from the TWLZ from the beginning of its activity until the end, and during the observed data collection period, more than 5600 Twitter users followed it [59]. In the current study, the tweet sample consists of a total of 2288 tweets reposted by the TWLZ bot from 25 April 2022 to 1 May 2022. The time frame of the tweet

sample (and connected survey with teachers) was chosen as it fell relatively in the middle of the first school year after pandemic-related school closures, and no federal state had holidays during this working week. This is crucial for investigating how teachers tweet in their actual school routines and not during distance teaching or holidays. Additionally, there are already several studies that have examined teachers' Twitter behavior during the pandemic [13,14]. Hence, this study could particularly connect well thematically by exploring a new observational period after the peak of the COVID-19 pandemic. The tweet sample was extracted from a Twitter archive file of the bot, which is a common alternative for generating tweet samples alongside the Twitter application programming interfaces (API) [11]. Tweets that were deleted by the original users were not considered in the sample. Using an archive file to extract tweets offers a good alternative and ensures a reasonably reliable data corpus, mitigating biases present in the Twitter Streaming API [60]. In further analyses, the features (e.g., engagements) of the original tweets of the users were examined, not the bot's retweets. This also included some tweets from bots that were retweeted by the TWLZ bot.

2.2. Survey Design (RQ1)

A quantitative survey with teachers (see Appendix A) was conducted to address the first research question concerning teachers' use of scientific evidence from the TWLZ in their classroom teaching and school practices.

First, it was ensured that all participants had read and accepted the consent form for the processing of their personal data. Subsequently, participants' TWLZ activity was assessed through a filtering question, commonly used for assessing activity on Twitter [12]. If the response indicated "never" active during the specified time frame, the survey was terminated immediately. Subsequently, participants were asked to provide general information about their age, years of professional experience, and the subjects they taught. The indication of the subjects taught was made through (multiple) selections from predefined subject categories. Additionally, both professional and personal usage of nine well-known social media channels was queried. For discussion purposes, only the top three channels are considered later; however, the complete dataset can be accessed online (see OSF). Following this, participants were asked, based on the findings from Krutka and Carpenter [49], what they use the TWLZ for. Responses to individual items (e.g., resource sharing/acquiring) were rated on a 4-point Likert scale (1 = never or almost never; 4 = always or almost always).

The second section of the questionnaire transitions to teaching-related questions. To align the TWLZ usage with evidence-based teaching, participants were subsequently asked about their sources of knowledge for methodological and didactic decisions in their teaching practice. Participants provided their responses based on a 4-point Likert scale (1 = never or almost never; 4 = in every lesson), using items (e.g., subjective or scientific theories) from the qualitative surveys conducted by Franke [52].

In the third section, the focus is on the transfer of research findings from the TWLZ into teachers' classroom practice. First, participants were asked to rate on a 4-point Likert scale (see Appendix A for detailed description of further scale levels) how often they see tweets in the TWLZ from (a) educational researchers, institutes, or ministries; (b) teachers; (c) companies (e.g., providers of digital learning software); or (d) individuals from other, unspecified categories. Based on this question, participants were asked how frequently materials and concepts from tweets seen from the mentioned categories of persons were subsequently implemented in their own teaching. Responses were provided on a 4-point Likert scale. For both the seen and implemented materials and concepts, there was also the option to choose "I cannot provide information about individuals in this category". Next, the frequency of the transfer of research-based tweets from the TWLZ to their teaching practice was assessed. The process of choosing innovative, research-based teaching concepts can be described in a five-stage model [61]. Based on the stages (a) Knowledge, (b) Persuasion, (c) Decision, (d) Implementation and Adaptation, and (e) Confirmation,

sample items were designed. These sample items (e.g., *Knowledge* = "I have seen scientific research findings and research-based teaching concepts in the TWLZ, *know* their functions, and how to apply them") were assessed using a 4-point Likert scale. At the beginning of the question, scientific research findings and research-based teaching concepts were explained as examples (e.g., insights into the use of digital media in science education or scientifically developed guidelines for the promotion of high-achieving students) to enhance participants' understanding. The last question in this section asks participants to describe in detail the opportunities and limitations they see when it comes to implementing scientific research findings, concepts, and recommendations in their teaching. Participants' open-ended responses were initially coded following Mayring's approach with inductive development of categories and deductive application of categories [62]. Two raters coded the responses from 17 teachers, and their agreement regarding the opportunities, as measured by Cohen's Kappa [63] (Cohen's $\kappa = 0.722$, $p < 0.001$), was considered to demonstrate a substantial level of agreement according to Landis and Koch [64]. With respect to the limitations of transfer, a nearly perfect agreement between the coders was achieved (Cohen's $\kappa = 0.813$, $p < 0.001$). At this point, the survey was not yet finished, as the quality characteristics of tweets were subsequently assessed. To maintain clarity in the methodological approaches for addressing each research question, this part of the survey will be presented in the following subsection.

Two rounds of pilot testing of the survey were conducted, and feedback from the testers was incorporated into the final questionnaire through revisions.

The descriptive data analysis of the survey was conducted using the IBM SPSS Statistics software, version 28.0. [65].

2.3. Analytical Hierarchy Process (RQ2)

The Analytical Hierarchy Process is a method for making complex decisions and is comparable to a utility analysis. This method was employed to address the second research question concerning the content-related, communicative, and interactive tweet preferences of teachers within the TWLZ. Before applying this concept to the tweets in the TWLZ, survey participants were shown example tweets. The example tweets (see OSF) can be categorized as (a) scientific research findings, (b) practical teaching concepts, and (c) daily exchange of experiences. These categories also reflect the previously mentioned categories of individuals (e.g., researchers, companies, teachers). The tweets intentionally differ by various qualitative attributes related to content, communication, or interaction (e.g., hashtags, language style, engagements, links). This question was chosen as an introduction to the AHP to illustrate quality attributes through tangible examples. This enhances participants' understanding of the AHP section, as survey participants from other fields of study often report struggles to grasp what they are required to do [66]. After participants selected their favorite tweet, they were asked to describe what they particularly liked about it and what they liked less about the other tweets. The responses from 26 teachers were initially coded openly and inductively following Mayring's approach [62], and initial categories were formed. Two raters subsequently coded these categories. In this process, the coding by the two raters showed substantial agreement [64] with Cohen's Kappa of 0.638 ($p < 0.001$). At the beginning of the actual AHP survey, participants were instructed to consistently choose between two quality attributes of tweets. They were reminded that the goal was not to make the "right" decision but to express their subjective opinion. Care was taken to enhance their understanding of the quality attributes through an overview graphic of the individual criteria and sub-criteria. This graphic is also included in the attached survey in Appendix A and can serve as a guide for the following explanations on AHP.

The top level (Level 1) of this AHP model refers to the quality attributes of tweets. The first specific question (Level 2) asks participants to select their preference among the three tweet categories (e.g., Content, or Communication, or Interaction). Preferences are elicited on Saaty's 9-point scale [67] and were adapted for the online survey tool survey (8 = extremely preferred, 4 = very preferred, 0 = equally preferred). In the online survey, the

corresponding attributes within the pairwise comparisons are juxtaposed, such as "Content" on the left and "Communication" on the far right, and participants evaluate them on a 9-point scale in both directions (see Appendix A, Question 14). The quality criteria of the tweets that are assessed and compared within the subordinate subcategories are based on previous Twitter analyses (see Introduction). Regarding the subordinate tweet categories, it is essential not to query and compare too many items or quality characteristics [68]. The following question applies the same principle to the three content-related tweet criteria (Level 3; e.g., scientific research findings, practical teaching concepts, or daily exchange of experiences). Next, the same question format is used for the four communicative tweet criteria (e.g., neutral technical language or well-known hashtags). Each item must be compared with each other item in at least one pairwise comparison [67]. Based on the number of items (n), the required number of pairwise comparisons can be calculated ($2n - 2$). It is also essential that the order of pairwise comparisons is randomized, and the comparison does not always start with the same item, as this could distort response behavior and lead to inconsistent responses. Finally, the four interactive tweet criteria are assessed using the same approach. Upon completing this question, the survey ends, and participants are directed to an end page.

Now, the AHP model evaluation is described in detail. Based on the responses, three results of the pairwise comparisons can be identified [69]: (1) the item on the left side is preferred (see Survey Data; Values 1–8; ratio 9:1); (2) both items are equally preferred (Survey Data Value 9; ratio 1:1); (3) the item on the right side is preferred (Survey Data Values 10–17, ratio 1:9). Averages of the pairwise comparisons are calculated using these individually determined ratios. This approach is particularly recommended to reduce the subjectivity of individual estimates and potential personal biases [70,71]. Following this, a consistency check was performed. To evaluate the consistency of the comparison matrix, Saaty [67] introduced the Consistency Index (CI). The calculation for CI is determined by the formula: CI = $(\lambda\max - n)/(n - 1)$. If CI is less than 0.1, then the response behavior can be considered consistent. Using the calculated averages, a total of four pairwise comparison matrices were created, one for the tweet criterion at Level 2, and three matrices for the tweet sub-criteria at Level 3. This was performed with the statistical software R version 4.3.1. Using CGI's AHP calculation software [72], the equation system was resolved to derive the resulting vector w, indicating priority factors. This vector was calculated for both the higher-level criterion and the three sub-criteria. The four pairwise comparison matrices and four preferences vectors can be found online in the survey data (see OSF). Regarding the pairwise comparison matrix for the tweet criterion (Level 2), an equal-weight distribution was initially assumed, which would have required a minimum sample size of 19 people [73]. This sample size was significantly exceeded with the present sample size of 26 people.

It should be noted that the overarching research objective of this study cannot be achieved solely through quantitative and partially qualitative surveys. To identify further connections between the tweets in the TWLZ and the teachers' attitudes, both quantitative and qualitative tweets analysis need to be conducted. Previous research frequently used mixed methods approaches for tweet analysis [13,48,50].

2.4. Tweet Analysis (RQ3)

The tweet sample is an important component in addressing the third research question, regarding characterizing (science-based) actual communication within the TWLZ. First, the features of the tweets that were collected to facilitate further analysis will be described. All tweets from the TWLZ bot archive file were assigned unique identifiers. Additionally, the names of the original tweet (not bot retweet) authors and the tweet content were extracted. The Twitter biographies of the most active TWLZ users were also analyzed and categorized (e.g., individuals, companies, educational experts) [11]. Other relevant tweet data that have frequently been collected in research (see Introduction) include the precise and complete date, the day of the week, and the time of the post. Furthermore, it was noted whether the

tweet contained multimedia content or a link. Multimedia content in this context refers only to self-uploaded images, videos, or GIFs. This does not include images from automatically attached website cards or images present in the retweeted original post. Linked content includes inserted websites or links, as well as retweets that link to a user's original tweet. Lastly, the engagements of each tweet were examined, including the number of replies, retweets, likes, and bookmarks. Although the tweet archive file is from July 2023, the engagement statistics of the original tweets are continuously updated. The collected data reflect the status as of August/September 2023. For easier analysis, the hashtags (#) and mentions (@) from the respective tweets were listed separately. Based on these collected features, a quantitative descriptive data analysis was performed in R and SPSS.

Subsequent qualitative data and text analyses were conducted using the software MAXQDA version 2022 [74]. This program was also used to conduct sentiment analysis of the tweets, a procedure often applied to German tweets in the field of education [11,40,45]. In this process, each word in a tweet is looked up in a lexicon and assigned a sentiment value. In cases of negation, such as "I was not very happy", the values of the following three words are reversed, thus classifying the previous statement as negative. For modal verbs like "can" or "should", the sentiment values of the following words are adjusted (e.g., "could be quite useful"). The mean value of the sentiment scores for individual words in a tweet is calculated, and the overall sentiment assessment for the entire tweet is based on this mean value: a negative mean value results in a sentiment of "negative" or "somewhat negative", while positive scores result in "somewhat positive" or "positive". If the mean value is close to zero or equal to zero, the text is classified as "neutral". Tweets without words with sentiment values are labeled "no sentiment" (e.g., Tweets like "WLAN Streaming App—ein Tipp für Schulen [external link] #Schule #Unterricht #MINT #twlz"). The existing emojis in the tweet cannot be assigned a sentiment value through this lexicon approach; they remain unconsidered.

Further analysis of the tweet content, more specifically the themes of the tweets, was conducted using the Automatic Text Response Coder (ReCo). The shinyReCoR app was employed for this purpose [75,76]. First, the tweet data were adjusted and imported into the app to identify unique text responses and manual codes. During data preprocessing, words were decapitalized, and umlauts, numbers, symbols, and punctuation were removed. Additionally, removing common stop words helped reduce the variance in tweets to make them more comparable. To prepare for the analysis of the semantic spaces, the general German language text corpus, based on Wikipedia articles, was supplemented with semantic vectors of the tweet sample, particularly concerning compound hashtags (e.g., #digitalebildung; #DieMaskeBleibtAuf; #TeamWissenschaft). The percentage of uncovered response tokens is relatively high with 10.2% [75]. This can be attributed to the size of the text corpus as well as the TWLZ-specific contents, which are inadequately represented in the corpus. Next, a Latent Semantic Analysis [77] was conducted within the shinyReCoR app, generating a vector for each preprocessed word from a tweet within the text corpus. The semantic space can be visually interpreted, and tweets can also be interpreted within the low-dimensional representation of the response semantics (see OSF). To identify thematic clusters of tweets, responses were clustered into response types according to their representation in the semantic space. To determine the similarity of response vectors, a commonly used method for tweets, distant measure cosine, and the k-means clustering method were applied [78], ultimately forming 100 clusters. This results in a cluster table detailing the distribution of categories and the distances from the center or average of all the points in the cluster in the multidimensional semantic space. Within the numbered clusters, "*n*" indicates how many tweets can be assigned to each cluster. Based on the details of individual clusters, the topics of the tweets can be roughly identified. The qualitatively formed thematic clusters ultimately reflect the tweet topics in the TWLZ. This approach, combining natural language processing and expert content analysis, has previously been employed in other thematic contexts [79], and with this study, the applicability in the education sector will be implemented.

3. Results

3.1. Descriptive Survey Results

General Information. The survey results indicate that the teachers who participated in the survey have an average age of 46.07 years (SD = 8.86), with a minimum age of 27 years and a maximum age of 66 years. Their average professional experience is 16.78 years (SD = 7.87), with a minimum of 1 year and a maximum of 36 years of experience. These teachers commonly teach 2 (n = 18) or 3 (n = 11) different subjects, with the majority focusing on STEM subjects (25 out of 41), followed by German (19) and social sciences (17). Detailed results can be found in Table A1 in Appendix B. The most commonly used social media platforms among teachers vary between professional and personal usage. Nearly all of the respondents indicated that they use Twitter for professional purposes (92.68%), followed by YouTube (73.17%) and LinkedIn (31.71%). For personal use, YouTube (75.61%) is more popular than Twitter (65.85%), closely followed by Instagram (63.41%). Also noteworthy is the high level of activity among the participants on Twitter. Out of 39 valid cases (2 missing), 10 individuals (24.39%) are active on TWLZ once or twice a week, and 29 individuals (70.73%) are active every day or almost every day. Based on their activity, teachers were also asked about their reasons for using the TWLZ. Most frequently, teachers use the TWLZ primarily as a digital professional development resource and for resource sharing/acquisition. Other purposes for using the TWLZ are presented in the following Table 1.

Table 1. Teachers' TWLZ (Twitter teachers' lounge) Usage.

	N		*M* *	*SD*
	Valid	Missing		
Digital professional development	40	1	3.28	0.75
Resource sharing/acquisition	39	2	3.10	0.88
Collaboration	39	2	2.41	0.97
Self-promotion	39	2	1.97	0.93
Emotional support	39	2	1.95	0.92
Twitter chats	40	1	1.53	0.78
Backchanneling (Live-Tweets during events/lessons/conferences)	39	2	1.41	0.6
In-class activities	39	2	1.18	0.51
Out-of-class activities	39	2	1.18	0.45
Communications with parents	39	2	1.05	0.22
Communication with students	39	2	1.03	0.16

* Mean values based on a scale (1 = never/hardly ever; 2 = in some cases; 3 = in most cases; 4 = always/almost always).

Sources of Knowledge. To bridge social media and TWLZ usage with evidence-based teaching, the sources of knowledge for methodological and didactic decisions in teaching practice were examined. Teachers indicated that their decisions were most often based on scientific theories (M = 3.13; SD = 0.65) and everyday-based experiences (M = 2.92; SD = 0.66) in the majority of lessons. Research-oriented knowledge (M = 2.48; SD = 0.82) and subjective theories (M = 2.34; SD = 0.75) were less commonly cited as sources of knowledge, being used in slightly more than some lessons.

Transfer. The focus is on understanding how often teachers see content, such as educational researchers' tweets in the TWLZ, and subsequently implement them. Teachers most frequently encounter tweets from other teachers several times a week to almost daily (M = 3.74; SD = 0.66), followed by tweets from companies approximately once a week (M = 2.69; SD = 0.9). Somewhat more often than once or twice a month, teachers read tweets from educational researchers (M = 2.47; SD = 0.86) or individuals from unspecified categories (M = 2.46; SD = 1.1). It is also worth noting what is implemented from what they have seen. Most frequently, teachers report to implement methods, etc., they have seen in the TWLZ from other teachers in slightly more than some hours (M = 2.24; SD = 0.55). This is followed by content from educational researchers in slightly less than some hours

(M = 1.86; SD = 0.6). Content from tweets by companies (M = 1.69; SD = 0.58) or individuals from other categories (M = 1.54; SD = 0.66) is implemented only slightly more than almost never in their teaching. The following Table 2 illustrates the tweet transfer.

Table 2. Scientific Tweets seen and implemented by teachers from the TWLZ.

	N			*M* *	*SD*
	Valid	**Missing**	**No Indication Can Be Given**		
Tweets seen from . . .					
Teachers	35	6	0	3.74	0.66
Companies (e.g., providers of digital learning software)	32	6	3	2.69	0.90
Educational researchers, institutes, ministries	34	6	1	2.47	0.86
People from other categories, not mentioned	24	7	10	2.46	1.10
Tweets implemented from . . .					
Teachers	34	7	0	2.24	0.55
Educational researchers, institutes, ministries	35	6	0	1.86	0.60
Companies (e.g., providers of digital learning software)	35	6	0	1.69	0.58
People from other categories, not mentioned	24	7	10	1.54	0.66

* Mean values based on a scale (1 = never/almost never; 2 = once/twice per month; 3 = once/twice per week; 4 = everyday/almost every day).

After examining that tweets from educational researchers, institutions, and ministries are seen relatively often but not implemented as frequently, it is particularly interesting to understand the reasons behind this implementation gap. The adoption of research findings into one's teaching is similar to the process of adopting and implementing innovations, as previously mentioned. Results concerning the stages of the innovation diffusion process show that the values for each stage are very close to each other (Min = 2.03; Max = 2.47). Most frequently, the implementation (with adaptation) of research findings in practice occurs more than once or twice a month but less than once or twice a week (M = 2.47; SD = 0.79). This is followed by the persuasion or assessment of research findings for their application in their own teaching (M = 2.32; SD = 0.77). Knowledge about how to implement research findings in teaching (M = 2.26; SD = 0.71) and the decision to do so (M = 2.21; SD = 0.81) occur at approximately the same frequency, which is somewhat more than once or twice a month. A bit less frequent is the confirmation of the implemented research findings in teaching by colleagues or students (M = 2.03; SD = 0.90). Regarding the transfer of research findings into practice, further relationships can be identified. Teachers whose teaching decisions are frequently based on scientific theories are more likely to achieve the transfer of research findings into practice in the form of convictions (r = 0.39; p = 0.02) and implementation (r = 0.47; p = 0.01). This correlation is moderately positive and significant. This relationship becomes even more pronounced when teachers primarily use research-oriented knowledge as the basis for their teaching decisions. Here, there are moderate positive correlations with the transfer into practice in terms of knowledge (r = 0.37; p = 0.03) and implementation (r = 0.48; p = 0.01), and even strong positive correlations for the transfer regarding conviction (r = 0.506; $p < 0.01$) and decision (r = 0.51; $p < 0.01$). All these correlations are significant.

3.2. AHP Tweet Characteristics Results

In preparation for the AHP survey, teachers were asked about their favorite tweet. Out of 28 participants, half of them favored a tweet from educational research (n = 14). In the second place was the sample tweet promoting practical teaching concepts from a company (n = 8). The least favorite, with six votes, was the sample tweet representing everyday experiences shared by a frustrated teacher. Answers to the question of why they chose this tweet revealed that appealing multimedia content (n = 11) and personal interest or relevance (n = 11) were particularly important. Also, of significance was that the tweet was engaging and interesting (n = 8), factual and not too emotional (n = 8), credible (n = 7),

focused on sharing experiences and collaboration (n = 7), free from advertising (n = 6), clear and concise (n = 6), provided recommendations for materials/events/tools (n = 6), directly implementable (n = 5), and scientifically grounded (n = 5).

The AHP results indicate inconsistent responses regarding the preferred tweet criterion (C.I. = 1.35227). The values illustrate that interaction (0.414) is more important than tweet content (0.309), with communication (0.277) just below. Since the response behavior is inconsistent at Level 2, no comparisons can be made between items of different sub-criteria (e.g., content and communication). At the underlying Level 3, the tweet sub-criterion "content" shows consistent response behavior (C.I. = 0.00914735). The most important criterion is practical teaching concepts (0.550), followed by everyday exchange of experiences (0.240) and closely followed by scientific research results (0.210). For the "communication" sub-criterion, the response behavior is consistent (C.I. = 0.0618392), and the most important aspect is neutral technical language (0.356). Following that are multimedia content (0.301) and well-known hashtags (0.248). The least popular aspect of communication is emotional everyday language (0.095). The response behavior for the "interaction" sub-criterion is consistent (C.I. = 0.0908288). The most important aspects are linked content (0.542), followed by engagements (0.258). The number of followers (0.137) and the status of whether the Twitter user is a verified account (0.063) are less important. In Figure 1 below, an overview of the weighting outcomes for the tweet criteria and three sub-criteria is provided. To enhance comparability, all weighting outcomes are displayed on a scale ranging from 0.0 to 0.6. The tweet quality criteria and sub-criteria are displayed based on their ranking of preferences. Additionally, the Consistency Index (C.I.) for each matrix is presented within parentheses adjacent to the weighting results in the Figure.

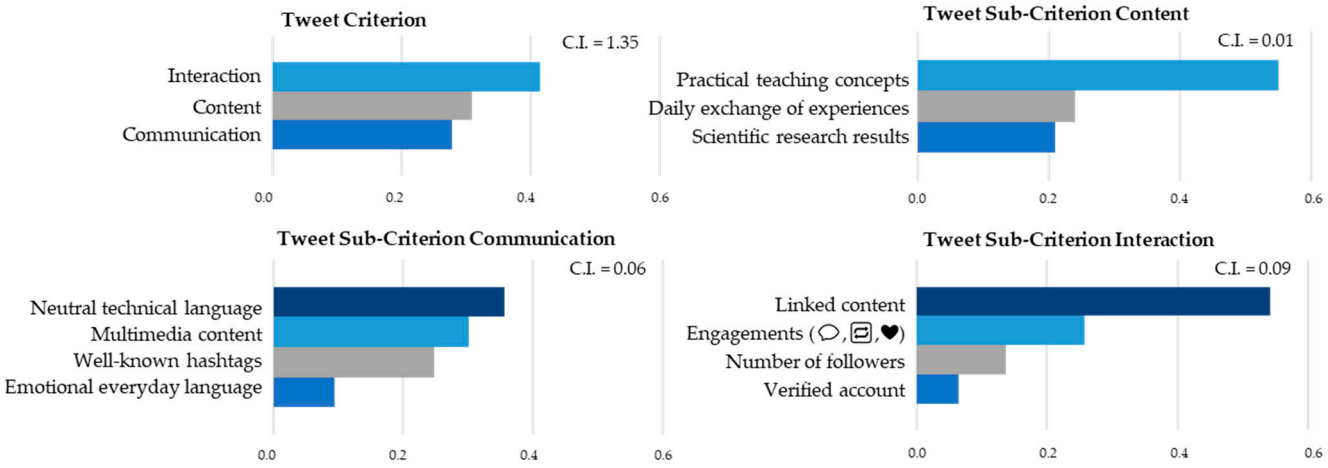

Figure 1. Overview of the weightings results for teachers preferred tweet features in the TWLZ.

3.3. Tweet Analysis Results

Tweet Authors. Regarding the tweet sample, various characteristics can be described descriptively. The 2288 tweets come from 991 tweet authors. More than half (63.87%; n = 633 individuals) of the authors have posted only one tweet. The top 10 most active Twitter users have posted 15–42 tweets per week, with the most active user posting 309 tweets per week. Approximately one-third of individuals fall in the middle range, posting 2–14 times per week (n = 348). Based on the Twitter biographies of the top 10 active users, the following categories can be identified. The majority of them can be categorized as (self-proclaimed) education experts. These include former teachers or individuals who share their knowledge and experiences in the form of tutorials and collections, often earning money from it (e.g., Grosty10, etTutorials, LearnAuf, coolschooltoday). There is also a (self-proclaimed) researcher (AnnaLyst_), two private individuals (alles_sophie, uberlauferin), an official account of the state of North Rhine-Westphalia (MKR_NRW), an initiative (oersaarland), and a provider of educational software (Malter365). It is important to note

that when looking at the 20 most active users, the categories are expanded to include five teachers. Additionally, it is worth mentioning that this is primarily about frequency (without considering the popularity of the posts), and some education experts may also be teachers but present themselves online as education experts.

Tweet Time. The number of tweets per day varies. Tweets are most frequent on Tuesday (n = 415) and Thursday (n = 400). The days Monday (n = 342), Wednesday (n = 369), and Friday (n = 336) are approximately equally popular. There is a clear trend indicating that tweeting during the workweek is much more popular than on weekends. After Friday, the least popular workweek day, Saturday (n = 220) and Sunday (n = 206) follow. The most popular time for tweeting is between 12:00 PM and 3:59 PM (n = 890). The least popular time is during the night (9:00 PM–5:59 AM) with a total of 259 tweets. In terms of teachers' working hours, it can be observed that 650 tweets are posted during the school hours (8:00 AM–12:59 PM). Another 511 tweets are posted between 1:00 PM and 3:59 PM. Most tweets are posted between 4:00 PM and 5:59 AM (n = 997), with the fewest tweets in the early morning before school (6:00 AM–7:59 AM) with 130 tweets.

Content. In regard to the content and interactions within the tweets, more than half of the tweets (69.45%) do not include any multimedia content. The remaining 30.55% (n = 699) of tweets include multimedia content. Approximately 53.06% of tweets contain linked content (n = 1214), while around 46.94% have no linked content (n = 1074). Hashtags are another important feature of the tweets, which will now be described. In total, 7825 hashtags were identified in the tweet sample, consisting of 2016 distinct hashtags with an average character length of 10. The most frequently occurring hashtag, with at least one occurrence, is #twlz, present in 94.97% of the tweets (n = 2188). Among the other top 10 hashtags, in descending order of occurrence, one can find: Schule (n = 274), Unterricht (n = 240), MINT (n = 215), Berlin (n = 210), FollowerPower (n = 124), twitterlehrerzimmer (n = 107), EDV (n = 78), Internet (n = 59), and Schulen (n = 52). The 25 most common hashtags can be illustrated in the following word cloud (Figure 2). In total, 1288 Twitter users were mentioned in tweets with the "@" symbol. Most frequently, YouTube (n = 53) was mentioned in the tweets, followed by mgrosty (n = 29), SlideShare (n = 28), TaskCards_ (n = 16), KM_Bayern (n = 13), KM_BW (n = 12), mobileschule (n = 11), blume_bob (n = 9), MKR_NRW (n = 9), and DKSB_Bund (n = 8). Among these mentions, there are primarily frequently used tools/companies like YouTube or TaskCards, as well as teachers with particularly high reach (blume_bob) and official accounts of German federal states like KM_Bayern, KM_BW, and MKR_NRW.

Engagements. Regarding engagements, the following Table 3 provides an overview. On average, posts are retweeted 2.86 times (SD = 12.03), but most commonly only once (by the TWLZ Bot). The highest number of retweets for a single tweet was 413. Replies are not very popular, with tweets usually having 0 replies (M = 0.2; SD = 1.31), with the most replies being 43. The average number of likes is 12.86 (SD = 126.90), but most tweets have only 2 likes. The most popular tweet has 5530 likes. Bookmarks are also not very common, with an average of 0.7 (SD = 3.31) bookmarks per tweet. Most tweets have 0 bookmarks, with a maximum of 98 bookmarks. The tweets with the five most retweets, replies, likes, and bookmarks overlap. Out of the theoretically possible 25 tweets, 12 tweets were included in the top tweet rankings. Upon examining these tweets, it is apparent that the tweet authors primarily belong to the categories of teachers (n = 7) and private individuals (n = 5). These 11 different tweet authors have an average of 6970 followers (SD = 10989.69). Due to the significant outliers (Min = 79; Max = 29,400), the mode is a more stable measure of central tendency, with a value of 1257 followers.

Figure 2. Overview of the 25 most popular hashtags from the TWLZ.

Table 3. Overview of tweet engagements in the TWLZ.

	M	*SD*	Median	Mode	Min	Max
Retweets	2.86	12.03	1	1	0	413
Replies	0.20	1.32	0	0	0	43
Likes	12.86	126.90	2	0	0	5530
Bookmarks	0.70	3.31	0	0	0	98

Sentiments. The emotional value of the 2288 tweets can be characterized by a total of 4645 positive words and 2633 negative words in the tweets. Further analyses show that 38.46% of the tweets are rather positive (n = 880), followed by neutral tweets (n = 712) and tweets with no sentiment (n = 335). Less frequent are rather negative tweets (n = 261) at 11.41%, clearly positive tweets (n = 74), or clearly negative tweets (n = 26).

Topics. The tweets were divided into 100 different clusters based on their representation in the semantic space. Since some tweet contents cannot be clearly assigned to a single cluster, only 52 thematically meaningful and consistent clusters were formed. The formation of themes is based on the tweet content within the clusters. For example, Cluster 7 primarily contains content from 23 tweets related to keywords like education research, program, pedagogy, conference, ministry, and training, thus receiving the overarching theme of "Science-Practice-Transfer". Using this approach based on the 52 thematically meaningful clusters, 22 themes were identified. The themes, along with the number of associated clusters (and the corresponding number of tweets in the clusters), are listed in Table 4 below. Occasionally, two closely related themes were assigned to one cluster to better characterize the topic of the tweets. For example, Cluster 92 was attributed with the thematic keywords teacher, teaching, education, learning, and university, representing both the themes of "education" and "professionalization". As a result, there are 64 multiple mentions in the table of the number of clusters. The most common themes relate to the use of Digital tools (n = 8), STEM (n = 7), and Science-Practice-Transfer (n = 7). When examining the details of the thematic clusters related to Science-Practice-Transfer, it becomes clear that this encompasses not only studies, research results, or universities but also specifically involves transfer through workshops, conferences, seminars, and lectures.

Table 4. Overview of the clustered tweet topics in the TWLZ.

Topic	Frequency Clusters	Tweets	Topic	Frequency Clusters	Tweets
Digital tools	8	159	Materials	2	48
STEM	7	165	Experiences	2	50
Science-Practice-Transfer	7	149	Non-German tweets (EN/FR)	2	48
COVID-19	6	101	Goals/Solutions	1	34
Professionalization	5	125	Days/Weeks/Vacation	1	33
Politics	4	94	Ukraine/Integration	1	25
Tips	3	72	Education law	1	24
Study program	3	72	Students/Class	1	20
School system	3	59	Social media	1	20
twlz	2	100	Positive emotions	1	20
Greetings	2	41	Education in federal states	1	16
Total				64	1475

4. Discussion

This section discusses the aforementioned findings in relation to the current state of research. Additionally, methodological and content-related limitations of the study are discussed, and recommendations for further research and practical implications are provided.

4.1. Teachers' Evidence-Based Teaching Practices (RQ1)

The first research question aims to determine whether and to what extent teachers utilize scientific evidence from the TWLZ in their teaching and school practices.

Regarding teachers' activity within the TWLZ, it can be reported that they are highly active, suggesting that there might have been some educational influencers among the respondents, potentially not representing the typical average teacher optimally. An enriching insight also refers to their activity on other social media channels. Particularly, YouTube and LinkedIn enjoy significant popularity from a professional standpoint. It is worth noting that professional use of social media differs from private use. Findings from this sample of teachers have shown a strong preference for Instagram for personal use. While teachers' activity on Instagram has been previously examined, the focus was mainly on its use for professional development and networking [80]. Unlike Twitter, Instagram is increasingly favored by educational institutions and teachers [6,81]. This indicates a need for further research and the identification of suitable channels for science communication with teachers. It is necessary to analyze which social media platforms are suitable for sharing research-based findings for professional development purposes. Moreover, there is a need for further research on the role of educational influencers on both Twitter and other social media platforms [56] to actively engage this group in science communication and leverage their extensive reach within the TWLZ.

The surveyed teachers most commonly use the TWLZ as a resource for digital professional development, consistent with previous literature findings [45,46]. Its advantages lie in the flexible utilization of offerings based on individual interests. However, potential downsides should not be overlooked. The risk of using it as a digital professional development resource lies in its informal nature and in lacking official recognition as a training measure. Furthermore, teachers utilize the TWLZ for resource exchange and collaboration, which aligns with existing findings [12,48]. Digital networking with other teachers is particularly effective during challenging times, countering isolation [50]. Additionally, teachers use the TWLZ more for self-promotion than for in-class or out-of-class activities or communication with students and parents. These results affirm existing findings [50,56]. It is worth noting that the self-promotion of educational influencers can serve as a central hub for knowledge exchange within a network. However, self-marketing can also solely pursue profit-driven purposes, which could contribute to making the TWLZ a less sociable place for teachers.

The sources of knowledge of teachers often show a balanced combination of scientific theories and everyday-based experiences. Subsequent to this, subjective theories and research-oriented knowledge appear at an equal level. These findings contrast with previous studies, which particularly emphasize the relevance of experiential knowledge and subjective theories [52] and emphasize the research and science-driven actions of teachers. This is especially present within teachers in Germany, who exhibit a significant level of trust in research outcomes, and, consequently, these trusted research findings are more frequently implemented when they reinforce the teachers' own subjective theories [82]. It also highlights that research findings are particularly effective sources of knowledge for teachers when illustrated and connected with their own experiences [83]. Research findings in this context not only include the transfer of scientific results from natural sciences to educational practices but also the significance of educational science for evidence-based teaching. There are already some interventions that highlight the importance of integrating scientific theories from educational research into teaching practice, presenting learning content in a context close to teachers' daily lives and thereby increasing motivation to use educational knowledge in teaching [84]. This study reveals rather great enthusiasm among teachers for science and research, holding substantial potential to affirm the attitudes of teachers in their roles as "teachers as researchers" [85]. Therefore, motivating teachers and assessing their knowledge bases and their usefulness becomes crucial for further promoting evidence-based teaching [86]. Studies suggest that teachers must believe in the usefulness and applicability of theory-based sources of knowledge to learn how to implement them effectively [87]. It is essential to note that the results are solely based on quantitative self-reports and not qualitative interviews or classroom observations. Therefore, teachers might have responded in a socially desirable manner, and the statements might not precisely reflect their daily classroom reality.

Additionally, notable insights directly related to the transfer of research findings from the TWLZ to the classroom have been highlighted. Teachers primarily encounter tweets from other teachers in the TWLZ, a pattern expected in a teachers' community, alongside businesses seeking to engage with this audience. Previous research identifies a similar distribution of user groups in Twitter teacher communities [11]. Surprisingly, despite the large number of official accounts from ministries of education, state institutes, and individual educational researchers, the indication "seeing a tweet from researchers or educational institutes and ministries slightly more than once a month" appears to be relatively low. This might be attributed to teachers' inability to immediately identify researchers or simply a lack of interest. On a positive note, ultimately, more content from researchers is implemented compared to that from companies, signifying enthusiasm for evidence-based teaching and successful knowledge transfer from science to practice. Contrary to expectations of the diffusion process of innovations, the implementation of research findings into practice occurs most frequently, more than once or twice a week. This surpasses existing research findings [51] significantly. While this is positive as teachers in their researcher role immediately apply new knowledge into practice [55], it can also be viewed negatively as it might suggest an unreflected adoption of scientific research outcomes. An unreflected adoption of teaching materials leads to poorer quality and sometimes hazardous knowledge dissemination [88]. Higher-level research concepts and models might facilitate a more reflective transfer of research findings in these instances [89].

In general, the assessments of the chances of transferring research results into practice are similar to those of previous research [15,50]. A rather strong orientation toward evidence is supported by teachers' anticipation of improved teaching from successful knowledge transfer between science and practice. Teachers are willing to adapt their knowledge and actions, viewing it as an opportunity for professional growth, self-reflection, and more theory-driven practices. Crucial for effective digital training offerings and sustainable changes in teaching are cognitive activation and collaboration among teachers [44]. These findings largely align with previous research [51,90] and make a significant contribution

to the German-speaking Twitter community of teachers. The greater the familiarity with research findings, the less teachers perceive limitations [91].

Nevertheless, there were also some notable limitations to transfer that were named in this sample of teachers. The most frequently mentioned hurdle of the lack of direct practicability also speaks for the unreflected use of evidence from the TWLZ. This aligns with previous research [92]. What seems to be missing is a critical reflective loop in applying and integrating this knowledge into practice effectively. This may also be attributed to the frequently mentioned lack of time and material resources [91]. There is often a lack of shared discourse between educational research and practice, where not only exemplary applications of research in teaching are showcased, but also the boundaries of application are discussed. This makes it challenging to derive clear recommendations due to conflicting, unclear, or qualitatively poor results, posing hurdles for both researchers and teachers [22,89]. In essence, the limitations highlighted here align with the existing body of research on teachers' utilization of scientific evidence and research findings [93]. Additionally, in a broader context, evidence-based practices not only confine decision-making to effectiveness but also restrict teachers' involvement in educational decisions. While educational policymaking on Twitter succeeds, broadening perspectives on research, policy, and practice is crucial to understanding education as a morally and politically complex domain, demanding ongoing democratic engagement [94].

In conclusion, the question remains as to why teachers, although not encountering scientific evidence frequently in the TWLZ, tend to implement the limited evidence relatively often in their teaching. This tendency is attributed to the theoretical and research-based knowledge sources of teachers, particularly emphasizing the direct applicability and the availability of individual and institutional resources.

Methodologically, several limitations need to be addressed at this point. The sampling of teachers was conducted through a non-random purposeful sampling method. The selection was based on the "expert status" derived from the frequency of activity in the TWLZ, including mostly highly active teachers in the sample. It is plausible that these teachers generally are more self-reflected in handling and integrating scientific research findings into their teaching. The average TWLZ user might not show as much interest in research findings and consequently implements them less frequently. This suggests a need for further research that compares the results of experts or highly active TWLZ users with the average TWLZ users. Additionally, the survey took place during a disruptive period when some teachers (including top educational influencers) had shifted to other platforms like Mastodon due to Twitter limitations imposed by Elon Musk [95], missing the call for survey participation on Twitter. Also, due to the Twitter API restrictions, a new TWLZ network analysis could not be conducted, and educational influencers in the TWLZ had to be identified and contacted based on an analysis from 2019 [57]. Both methodologically and contextually, adding qualitative questions about the actual implementation of research findings from the TWLZ would have provided valuable insights. Teachers could have precisely reported whose content they adopted, how they organized the content, and how they ultimately implemented it. This could have yielded further quality indicators of successful tweets. However, this remains a recommendation for future research, whereas the conducted AHP analysis also provides highly meaningful insights on this area.

4.2. Teachers' Preferences for Science Communication on Twitter (RQ2)

In the second research question, the aim was to determine how science communication in the TWLZ should be shaped for and by teachers.

Utilizing an AHP model, it was generally observed that in tweets, teachers prefer interaction over content and find communication to be least important. Content refers to the subject matter and topics of the tweets. Communication, in this context, is less about the interaction itself and more about how information is presented within the tweets. In this context, interaction refers to preferences such as direct engagement with others under tweets or linked content that directs interaction to other websites. This highlights a significant need

for action in science communication, since teachers desire interaction with universities, yet university tweets are seldom dialogue-oriented, mostly being self-referential [5,6]. There are already several models on how researcher–teacher relationships can be formed to encourage teachers' adoption and implementation of research findings [96], which this study builds upon and contributes to. Methodologically, it should be noted that the response behavior at this level (2) was inconsistent. Some teachers' responses significantly favored communication over interaction, making the mean decision highly subjective. Employing an algorithm in subsequent analyses to adjust this inconsistency might be beneficial [97].

At level 3, regarding tweet content, practice-oriented teaching concepts were more favored than sharing everyday experiences. Scientific research findings were the least favored. This seems to be logical, as teachers primarily use the TWLZ for resource sharing and acquiring, yet it also indicates a willingness to directly and perhaps uncritically incorporate practical teaching concepts observed in the TWLZ into their own teaching. Particularly interesting is this result when compared to teachers-selected favorite exemplary tweets, where the scientific tweet was significantly favored, followed by the practice-oriented teaching concepts of an educational software company. The teacher's exemplary tweet was the least favored. One should methodologically criticize the potential bias in teachers' responses. The teacher's example tweet was highly emotional and negative. Perhaps an extremely positive and optimistic tweet might resonate better with teachers. This suggests that additional (communicative) quality indicators in tweets are of importance.

Regarding tweet communication, neutral technical language was slightly more crucial than multimedia content. Recognizable hashtags were of less importance, while emotional everyday language was notably most unpopular. Contrary to previous research findings [93], teachers prefer complex technical language. Considering the primary use of the TWLZ (professional development and the exchange of resources), the preference for neutral technical language is not surprising. Targeted communication on specific relevant content (e.g., digital self-regulated or problem-oriented learning) can be conducted. This supposition aligns with teachers' statements regarding their selected exemplary favorite tweets. Personal engagement or interest and multimedia content were deemed particularly attractive by teachers. The tweets within the TWLZ showcase various multimedia content like images, GIFs, and videos, which can enhance the effectiveness of a tweet, especially in personal informal communication [39]. However, teachers might find the use of more than 10 hashtags, often employed in the TWLZ to garner attention, disruptive and less informative.

Results related to the interaction criterion of tweets indicate that linked content is more important than engagements. This aligns with teachers' desire for immediately usable teaching materials, likely shared via tweet links, and their general preference for interaction, generating more engagements in the form of likes, retweets, and replies. These findings correspond to previous studies, highlighting teachers' use of Twitter for obtaining teaching materials and digital tools in the form of links [14,49]. The number of followers and account verification appear to play a considerably smaller role for teachers. However, other sources indicate that to maintain authenticity, an account should not follow too many users [98]. Research also reveals that users are aware that an account's credibility is not solely linked to its verification status, and the blue checkmark on Twitter alone does not encourage users to share tweets [99].

In conclusion, the second research question emphasizes that scientific communication for and with teachers in the TWLZ should ideally be interactive. Teachers mainly prefer practical teaching concepts, neutral technical language, and linked content in a tweet. Emotional everyday language should be avoided, and the verification of the tweeting account seemingly does not matter to teachers.

However, at this point, methodological and content-related limitations need discussion. Methodologically, as mentioned earlier, the response behavior at level (2) of the tweet criterion in the AHP model was inconsistent, possibly due to competing preference

relationships [100]. This inconsistency may also arise from extreme favoritism of one of the features, which balances out in the mean. The inconsistency might also be due to inadequate information or introduction to the AHP model methodology in the survey, potentially leading to less reflective responses from teachers. Particularly noteworthy methodologically is that the AHP method has never been employed at the intersection of educational research, science communication, and Twitter analysis. The expert status was measured based on activity in the TWLZ in this study. However, it remains uncertain whether frequent activity in the TWLZ or the status of "educational influencer" indeed justifies an expert status. Conversely, it is also worth considering if possessing this expert status is necessary for evaluating tweet quality criteria or if a survey with a representative sample of all teachers in the TWLZ would be more informative. Although the results of the AHP method provide a solid basis and recommendation for science communication, it is advisable to examine in further research if these findings are replicable with another "expert group". Additionally, exploring group-specific differences in preferred quality indicators could be interesting. Factors like the subject taught or the most frequent use of the TWLZ might influence tweet preferences. Furthermore, from a content perspective, only elementary quality features were incorporated into the survey. More in-depth and specific syntactic and semantic tweet properties could have been queried. Subsequent research could, for instance, analyze everyday and technical language separately from sentiments or specific emotions (pride, anger, euphoria, despair). To maintain an appropriate level of cognitive load for teachers in the survey, no more than +/− 7 items were queried [68].

4.3. TWLZ Tweets and Their Role as a Catalyst for Professional Development and Science-Practice Transfer (RQ3)

The third research question aims to characterize (science-based) communication within the TWLZ. Addressing this question provides opportunities for science communication, professional development, and promoting evidence-based teaching, which will also be discussed here in connection with the two previously answered research questions.

Communication within the TWLZ is predominantly shaped by the involved users and their tweets. Results from the TWLZ tweet sample analysis reveal that 2288 tweets originated from 991 authors. Most authors contributed only one tweet, but there were notably more active authors posting between 15 and 309 tweets per week. Interestingly, the most frequent tweet authors are (former) teachers who now operate as self-proclaimed education experts, educational influencers, or entrepreneurs. However, actively practicing teachers are scarcely found among the top 20 tweet authors. Consistent with previous research [39], the most frequent tweet authors show relatively low engagement, making their tweets less effective. Official accounts (e.g., MKR_NRW, oersaarland) rank among the top 10 tweet authors, while distinctly identifiable educational researchers do not. This aligns with teachers' self-reports that they primarily see or engage with content from other teachers or companies.

Considering teachers' professional use of the TWLZ, the most popular times for tweeting are weekdays, particularly on Tuesdays and Thursdays. In this sample, Friday and especially the weekend are the least favored. This contradicts previous research [11,101], which identified Sunday as the most active day, though this research did not exclusively focus on the professional use of Twitter. A plausible conclusion could be that while teachers might engage more with Twitter for personal use on weekends, their professional use is certainly centered around weekdays. Most TWLZ activities occur in the afternoon around 4 PM, aligning with the time that teachers leave school, share experiences, or seek materials for upcoming classes. In further research, it is necessary to additionally differentiate regarding peak engagement tweet times since this study only captured general peak tweet traffic. Interestingly, top tweet authors such as Grosty10 and etTutorials have also posted tweets in the middle of the night, suggesting the potential involvement of semi-automated bots [102].

Communication within the TWLZ can also be characterized by tweet content. Only 30.55% of tweets contain multimedia content, aligning with preferences for communicative tweet content based on AHP. The presence of linked content in only 53.06% of tweets seems unexpected considering the clear preference for interactive tweet features. However, this can be attributed to the TWLZ's function as a resource hub, where linking may not always be necessary or appropriate. Results regarding the promotion of evidence-based practices through Clearing House institutions also indicate that teachers can better integrate research findings into their teaching when links are available [89]. The most popular hashtag in the Twitter teacher's lounge is #twlz by a significant margin. On average, a tweet contains 3.42 hashtags, falling within the effective tweet range [39]. Mentions average 1.78 per tweet, primarily involving accounts related to digital tools, (learning) software companies, education influencers, and official accounts. Tweets focus on resource exchange, such as utilizing @YouTube for teaching. However, numerous tweets also mention accounts with a large number of followers to increase reach or highlight current educational and societal issues (e.g., by AnnaLyst_). Consistent with prior research, tweets with more than eight mentions obtain fewer engagements in the TWLZ [39].

Findings on tweet engagements are also noteworthy. Given that average statistics for likes, retweets, and bookmarks are heavily skewed by outliers, the focus should be on the most frequent (mode) engagements. Most tweets have one retweet, zero replies, three likes, and zero bookmarks. These findings seemingly contradict teachers' preference for interaction, which could be achieved through replies and retweets. One explanation could be the substantial retweeting activity of the TWLZ bot. Between April and May 2022, the @Bot_TwLehrerZ alone reposted 17,726 tweets [59]. Similar results align with previous research, indicating that users actively follow an account even if they find only 36% of the tweets interesting and readable [38]. Nonetheless, it is noteworthy that the most popular tweets, receiving high engagement statistics, originate from private individuals or teachers rather than educational influencers or companies. The previously discussed factor of direct involvement or interest in favorite tweets might account for this high level of engagement.

Sentiments are also crucial in characterizing (science-based) communication within the TWLZ. Most tweets are formulated rather positively or neutrally, aligning with the preference for neutral technical language in communicative tweet features (AHP). These findings support Rosenberg's [103] observations and significantly contribute to the German-speaking TWLZ community. Clearly positive or negative tweets constitute only a few, accounting for a total of 4.37% tweets. It would be methodologically advisable to reevaluate sentiment analyses using different models and approaches. The application of Bidirectional Encoder Representations from Transformers (BERT) models can accurately assess tweet sentiments [104]. Furthermore, future research should integrate emoji sentiment values [105] since emojis are frequently used in TWLZ tweets but were not explicitly analyzed in the present study. While there are already well-trained language models for German tweets [40], accurately assigning colloquial and sarcastic wording from TWLZ users to their correct sentiments remains questionable.

The characterization of science-based communication within the TWLZ can primarily be discussed based on tweet topics. Twenty-two topics were identified based on semantic clustering. In some clusters, two topics were assigned to one cluster to provide a more specific description. Digital tools or digitization remains the most prominent topic in the TWLZ [12,14], followed by STEM topics, reflecting the high activity of STEM teachers and the content targeted at this audience by educational influencers and companies. Despite the lower visibility of researchers, institutions, and ministries, the transfer of educational science to practice ranks as the third most frequent topic within the clusters. This involves less direct sharing of published studies and places more emphasis on transfer formats for educational practice, such as workshops, conferences, or seminars hosted by researchers or universities. Similar connections between tweeting about scientific content and practical transfer formats are also prominent in other disciplines [7]. This illustrates the desire for both scientists and practitioners to engage in dialogue, resulting in extensive science

communication. Despite initial expectations for the specifically chosen time period after the pandemic, there are still tweets regarding handling COVID-19 in schools [13,106] and heated discussions about the German school system or educational policies [103]. Current topics from spring 2022 are also reflected in TWLZ communication, with teachers tweeting requests for help or tips for accommodating and integrating refugee students from Ukraine. Thematically, these tweets align with previous research on attitudes toward integrating foreign students and effective teaching methods for this group [107]. As a methodological limitation, it is worth noting that 48 of 100 clusters could not be assigned to a single theme during clustering. This indicates an inadequate coverage of tweet vectors in the semantic space, likely due to the combination of everyday language used in the TWLZ with technical educational terms. Future research could explore identifying tweet topics using a promising combination of Named Entity Recognition [108] and topic modeling to identify trending topics in the TWLZ [109].

To conclusively answer this third research question, it is necessary to differentiate between general and scientific communication. The primary tweet authors are not science-related; they tweet frequently but not necessarily with high tweet engagements. Researchers or educational institutions are frequently mentioned and also tweet regularly. Science communication predominantly focuses on transfer formats for educational practitioners.

At this point, some content-related and methodological limitations regarding the third research question should be addressed. It would have been insightful to collect additional user data from Twitter, such as location, number of followers, past tweets, and their duration of activity on Twitter or the TWLZ. Detailed biographies provided by Twitter users in their profiles would have added value to categorizing users. However, due to the complexity of manually or technically extracting this data without access to the Twitter API, it was not feasible within a reasonable cost-benefit framework. The completeness and scope of the tweet sample also warrant methodological discussion. Regardless of whether tweets are extracted from an archive file or via the Twitter API, data losses and incomplete samples are anticipated [60], for instance, due to deleted tweets that are untraceable even if retweeted (by the TWLZ bot). Employing the Twitter API could have generated significantly more tweets than this manually extracted tweet sample. However, due to the termination of the free Twitter API access in February 2023, this was no longer technically possible. Concerning the tweet sample, the number of tweets can also be discussed. The existing tweet sample is already (too) extensive for purely qualitative non-automated analyses, in accordance with previous qualitative research [110]. However, for purely automated quantitative analyses, the sample was too small. To obtain a representative sample for a school semester, random sampling over at least 7 to 8 weeks would have been necessary [111]. Despite various unforeseen limitations imposed by Twitter, this study contributes significantly to the methodological and content-related aspects of Twitter analyses within the TWLZ. In this context, it is noteworthy to mention that the methodology employed in this study remains replicable for other researchers, despite the current limitations imposed by Elon Musk and X.

In addition to content-related and methodological limitations, there are further constraints for tweets as catalysts for professional development and the transfer of science to practice, related to the shift from Twitter to X. Since Elon Musk took over Twitter, there are some restrictions affecting both educational research and practice. Content moderation on X poses challenges related to misinformation and hate speech. The previously mentioned shutdown of the Twitter API makes it challenging for researchers to examine the rapid rise in hate speech, and they are threatened with lawsuits by Elon Musk. Additionally, researchers lose visibility as they are unwilling to pay for a verified status [112]. Due to the significant increase in trans- and queerphobia, racism, antisemitism, and other hostile content, X might be no longer sustainable for public institutions, such as the German Anti-Discrimination Office, who chose to lead by example and left the social network [113]. Furthermore, large companies (e.g., ed-tech providers) that once advertised on Twitter are disappearing from X more and more, due to an increase in drop shipping ads and

adult content (e.g., not safe for work pictures and porn) [114]. This poses a threat to the TWLZ; as irrelevant content and ads are increasingly displayed, this can make it more challenging for teachers to access reliable research results. The more time they have to spend on finding research results, the more they perceive those results as irrelevant to their teaching practice [91]. This might reduce the significance of the TWLZ as a digital professional learning network, transforming it into an anti-social platform where teachers unproductively waste their time. Nevertheless, the future of teacher communities on X depends on various social influencing factors. Communities often migrate from Twitter to other platforms such as Mastodon when there is a low density of social connections, a higher degree of engagement for joint migration, and a stronger emphasis on shared identity in addition to exchange of factual knowledge in community discussions [115]. However, the TWLZ continues to have the potential to form an active community on X, as teachers engage to varying degrees. Mere lurkers or consumers may drift to different platforms such as Mastodon or Bluesky, but active contributors, curators, meta-designers, or moderators will probably remain active on X within their teacher sphere [116].

5. Conclusions

The results of this study are of great importance for teachers, researchers, and their institutions concerning science communication and its resulting promotion of evidence-based teaching. Building upon existing research on science communication on Twitter, teachers' professional learning networks on Twitter, and evidence-based teaching practices, this study provides added value by intertwining all three areas, thereby addressing a significant research gap. This study makes an important research contribution, bridging the gap between science communication on social media networks like Twitter, which teachers use as a professional learning and development network, potentially fostering evidence-based teaching. The teacher survey revealed that teachers are generally open to using scientific insights as a source of knowledge and occasionally integrating research-based concepts into their teaching. The evaluation of quality attributes in scientific tweets demonstrated that teachers highly value interactive, practical, and linguistically neutral tweets with linked content. The communication within the TWLZ is characterized as highly diverse. However, the transfer of educational science into practice is thematically crucial, though only visible through a few researchers or universities with relatively low tweet engagements. The outcomes of this study can assist researchers and universities in communicating their research findings in a more appealing and target group-oriented manner. Additionally, the study serves as an incentive for teachers to reflect on their own Twitter usage and attitudes towards scientific research results and evidence-based teaching. Further research in this context is highly recommended and crucial to fostering the transfer of science into practice and improving teaching through evidence-based practices.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board from the data protection officer at Technical University of Munich (VT-946; 11.08.2023) for studies involving humans.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Informed consent for the tweet analyses was given, as all Twitter users have agreed to the general

terms and conditions, including the publication and further dissemination of their posts and publicly accessible data.

Data Availability Statement: The data presented in this study are openly available in Open Science Framework (OSF) at https://osf.io/qe4xy/ (accessed on 10 February 2024).

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Appendix A

(Translated) Teacher Survey and Analytical Hierarchy Process Questions

1. **How active have you been in the Twitter teachers' lounge (TWLZ) in the period from February 2022 to September 2022?** Please choose.
   ☐ Never ☐ Once or twice a month ☐ Once or twice a week ☐ Every day or almost every day
2. **How old are you?**

   _____ years
3. **What school subjects do you teach?** Please choose.

   ☐ German
   ☐ Foreign languages (English, French, Latin, Spanish)
   ☐ STEM (Science, Technology, Engineering, Mathematics)
   ☐ Social Sciences (History, Geography, Social Studies, Economy, Law, Psychology)
   ☐ Music, Art
   ☐ Religion, Ethics, Philosophy
   ☐ Physical Education
   ☐ Professional subjects (e.g., medical assistance, office processes, technical drawing)
   ☐ Other _____
4. **How long have you been teaching?**

   _____ years
5. **Which social media channels do you use privately and professionally?** Please choose.

	private	professional
Facebook	☐	☐
Instagram	☐	☐
YouTube	☐	☐
Twitter	☐	☐
TikTok	☐	☐
Pinterest	☐	☐
Snapchat	☐	☐
Xing	☐	☐
LinkedIn	☐	☐

6. **What do you use the "Twitterlehrerzimmer" for?** Please choose.

	Never/hardly ever	in some cases	in most cases	always/almost always
Resource sharing/acquiring	☐	☐	☐	☐
Collaboration	☐	☐	☐	☐
Twitter chats	☐	☐	☐	☐
Networking	☐	☐	☐	☐
Backchanneling	☐	☐	☐	☐
Emotional support	☐	☐	☐	☐
Communication with students	☐	☐	☐	☐
Communication with parents	☐	☐	☐	☐
In-class activities	☐	☐	☐	☐
Out-of-class activities	☐	☐	☐	☐
Digital professional development	☐	☐	☐	☐
Self-promotion	☐	☐	☐	☐

7. **What are your methodological and didactic decisions based on in teaching practice?** Please choose. In a typical lesson of mine, my decisions are based on. . .

	Never/ almost never	few lessons	most lessons	every lesson
everyday-based experiences (context-dependent application and testing of approaches)	☐	☐	☐	☐
subjective theories (evaluations, attitudes, assumptions)	☐	☐	☐	☐
scientific theories (technical knowledge & terms, teaching & learning models)	☐	☐	☐	☐
research-oriented knowledge (scientific publications, study results)	☐	☐	☐	☐

8. **How often do you see materials, concepts, and tools from the "Twitterlehrerzimmer" from people from the following categories?** Please choose. Material, concepts and tools in the Twitterlehrerzimmer from. . .

	Never/ almost never	once/ twice per month	once/ twice per week	everyday/ almost everyday	can't provide information
. . . Educational researchers, Institutes, Ministries	☐	☐	☐	☐	☐
. . . Teachers	☐	☐	☐	☐	☐
. . . Companies (e.g., providers of digital learning software)	☐	☐	☐	☐	☐
. . .People from other categories not yet mentioned	☐	☐	☐	☐	☐

9. **How often do you use the materials, concepts and tools you have seen from the "Twitterlehrerzimmer" of people from the following categories in your school and teaching practice?** Please choose. Material, concepts and tools in the Twitterlehrerzimmer from. . .

	Never/ almost never	once/ twice per month	once/ twice per week	everyday/ almost everyday	can't provide information
. . . Educational researchers, Institutes, Ministries	☐	☐	☐	☐	☐
. . . Teachers	☐	☐	☐	☐	☐
. . . Companies (e.g., providers of digital learning software)	☐	☐	☐	☐	☐
. . .People from other categories not yet mentioned	☐	☐	☐	☐	☐

10. **How often do you successfully transfer science-based tweets from the "Twitterlehrerzimmer" in your classroom?** Please choose.

Scientific research findings or science-based teaching concepts refer to, for instance, insights into using digital media in science classes or scientifically developed guidelines to support exceptionally high-achieving students.

	Never/ almost never	once/twice per month	once/ twice per week	everyday/ almost everyday
Knowledge: I have seen scientific research results and science-based teaching con-cepts in the TWLZ, knows what functions they have and how they are to be applied.	☐	☐	☐	☐
Persuasion: I assess the usefulness of scientific research results and science-based teaching concepts from the TWLZ for my lessons.	☐	☐	☐	☐
Decision: I use scientific research results and science-based teaching concept from the TWLZ into my lessons.	☐	☐	☐	☐
Implementation and Adaption: I use scientific research and science-based from the TWLZ, adapt and change them.	☐	☐	☐	☐
Confirmation: I reflect (together with students/teachers) on whether the use of scientific research results and science-based teaching concepts from TWLZ were useful and profitable.	☐	☐	☐	☐

11. **What opportunities and limitations are there when transferring science into practice?**

Please describe in detail what opportunities and limitations you see when it comes to applying scientific research findings, concepts and recommendations in your teaching.

Opportunities: Limitations:

12. **Which tweet* is most appealing to you?** *see OSF files for German exemplary tweets

1☐ 2☐ 3☐

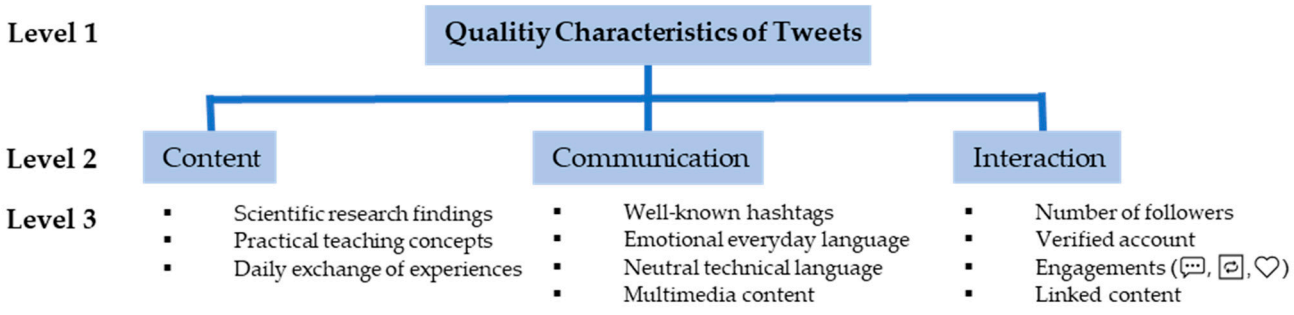
13. **Why did you choose this tweet?**

Please describe what you particularly like about the selected tweet or what you don't like about the other tweets.

In the following you will be asked to choose between two quality characteristics of tweets. It's not about making the right decision, but purely about your subjective opinion. Your answer will help us to make comparisons for the individual quality characteristics, to determine priorities and ultimately particularly identify relevant quality characteristics. This procedure is similar to a utility analysis.

Quality characteristics of Tweets

The following criteria and sub-criteria of quality features of tweets are queried and compared below



14. **What is important to you in a tweet?**

Please select which tweet criteria you prefer. 8 = extremely preferred 4 = very preferred 0 = equally preferred

Content or Communication

8☐ 7☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐ 0☐ 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐

Communication or Interaction

Interaction or Content

15. **What is important to you in a tweet?**

Please select which tweet content criterion you prefer. 8 = extremely preferred 4 = very preferred 0 = equally preferred

Scientific research results	or	Practical teaching concepts
Practical teaching concepts	or	Daily exchange of experiences
Daily exchange of experiences	or	Scientific research results

16. **What is important to you in a tweet?**

Please select which communicative tweet criterion you prefer. 8 = extremely preferred 4 = very preferred 0 = equally preferred

Multimedia content	or	eutral technical language
Emotional everyday language	or	Well-known hashtags
Multimedia content	or	Emotional everyday language
Multimedia content	or	Well-known hashtags
Emotional everyday language	or	Neutral technical language
Neutral technical language	or	Well-known hashtags

17. **What is important to you in a tweet?**

Please select which interactive tweet criterion you prefer. 8 = extremely preferred 4 = very preferred 0 = equally preferred

Engagements	or	Linked content
Linked content	or	Verified account
Number of followers	or	Linked content
Verified account	or	Engagements
Verified account	or	Number of followers
Engagements	or	Number of followers

Appendix B

Table A1. Description of teacher sample characteristics.

		Frequency	Percentage
Grouped age in years			
	20–29 years	1	2.44%
	30–39 years	8	19.51%
	40–49 years	19	46.34%
	50–59 years	10	24.39%
	60 years or older	3	7.32%
Grouped working experience in years			
	0–9 years	8	19.51%
	10–19 years	20	48.78%
	20–29 years	10	24.39%
	30–39 years	3	7.32%
Teaching Subjects			
German	No	22	53.66%
	Yes	19	46.34%
Foreign languages (e.g., English, French, Latin, Spanish)	No	27	65.85%
	Yes	14	34.15%
STEM (Science, Technology, Engineering, Mathematics)	No	16	39.02%
	Yes	25	60.98%
Social Sciences (History, Geography, Social Studies, Economy, Law, Psychology)	No	24	58.54%
	Yes	17	41.46%
Music, Art	No	34	82.93%
	Yes	7	17.07%
Religion, Ethics, Philosophy	No	35	85.37%
	Yes	6	14.63%
Sport	No	33	80.49%
	Yes	8	19.51%
Professional Subjects (e.g., medical assistance, office processes, technical drawing)	No	37	90.24%
	Yes	4	9.76%

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