

## *Elementary school students' information literacy: Instructional design and evaluation of a pilot training focused on misinformation*



### Peer-reviewed article

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### ABSTRACT

Online news literacy training has been so far insufficiently conducted and evaluated, and even less so with younger news consumers. Against the backdrop of online news cognitive processing, interventions against misinformation, and inquiry-based learning, we designed, conducted, and evaluated a pilot online news literacy training with 36 elementary school students from Germany. In a causal comparison, quantitative data from  $N = 29$  students attest high participant acceptance and substantial effects of the inquiry-based training on participants' ability to correctly assess online news credibility, and on the corresponding cognitive processing route, moving this from intuitive to analytic processing. Despite the small sample, the experiment was only underpowered regarding the between-subject effect, whereas the power was sufficient for all other effects. These encouraging findings of the pilot training may be the result of knowledge reorganization associated with inquiry-based learning. Further educational research and practice are needed to understand the efficacy of the training at scale.

**Keywords:** *misinformation, information literacy, elementary school, cognitive processing route, inquiry-based learning.*



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## INTRODUCTION

With the increasing use of digital media among children (Feierabend et al., 2021), their susceptibility to misinformation and fake news is also increasing (Carter et al., 2021; Maftei et al., 2022; Queiroz De Jesus & Hubbard, 2021).

Similarly to advertising, disinformation may generally aim to covertly influence attitudes and persuade target persons to a certain, not necessarily desirable, behavior (commercial, political, social, health-oriented, etc.). Children in particular between the ages of seven to nine years are not naturally able to assess news with regards to its credibility, even after receiving credibility warnings (Roberts et al., 2021). Consequently, the cognitive integration of misinformation fosters misconceptions that can affect the everyday lives of individuals and society in the long term (Pennycook, 2022).

To avoid negative consequences of disinformation and misinformation, many authors (e.g., Corser et al., 2022; Dumitru, 2020; Loos et al., 2018; Nagel, 2022; to cite only a few of the most recent publications), call for educational interventions aimed to improve children's information literacy related to online news. In response to this, we aimed to design, conduct, and evaluate an online news literacy pilot training for elementary school students. Correspondingly, the remainder of this paper includes a literature overview on misinformation and information literacy, the cognitive processing of online news, and possible interventions to foster information literacy.

Based on these theoretical considerations, we propose an inquiry-based pilot training for elementary school students that we subsequently evaluate in terms of participants' credibility evaluation discernment of true and fake news and cognitive processing improvement. Finally, we draw conclusions about information literacy interventions at early ages.

## THEORETICAL FRAMEWORK

The theoretical framework outlined below starts with definitions of key concepts and outlines our understanding of Internet users' cognitive processing of online information. Against this background, we discuss interventions aimed to increase Internet users' information literacy related to misinformation. We further suggest an instructional design for such interventions, along with basic evaluation criteria.

## Misinformation, disinformation, fake news, and information literacy

Mass media are generally expected to provide consumers with truthful information, which in turn requires journalistic quality assurance. If news quality is not provided, media propagate misinformation. When this happens intentionally, we label it disinformation. Within this latter genre, fake news is defined as news articles with verifiably false content, aiming to mislead news consumers, therefore mimicking the form of professional news media (Lazer et al., 2018).

Among multiple research domains investigating this phenomenon, the production, propagation, and reception of misinformation stands in the focus of communication research. The cognitive processing of misinformation and persuasion through disinformation are well-established topics of social psychology and, increasingly, of cognitive psychology (Pennycook, 2022). Building upon conceptual approaches and empirical findings, the educational sciences aim to foster news consumers' information literacy, training them to think critically and recognize misinformation as such, and to resist persuasion attempts through disinformation.

## Cognitive processing of online news

From a cognitive perspective, information consumers can fall for fake news due to several effects. For instance, the illusory truth effect supports the reception of information by increasing the belief in repeated propositions (Hasher et al., 1977). The mere exposure effect may cause a positive evaluation of something that was previously evaluated neutrally (Zajonc, 1968). Confirmation bias makes people more likely to actively search for and integrate evidence that supports personal assumptions and beliefs (Nickerson, 1998). Altogether, these effects contribute to cognitively integrating misinformation and developing misconceptions.

On the other hand, discarding or ignoring misinformation and thus resisting persuasion attempts requires three types of knowledge described by Friestad and Wright's (1994) persuasion knowledge model (PKM). First, topic knowledge enables news recipients to make sense of the message. Second, persuasion knowledge includes news consumers' beliefs about what a persuasion episode is and how they could be persuaded. Third, agent knowledge consists of assumptions about an agent's motives, goals, and

strategies behind a persuasion attempt. A meta-analysis by Eisend and Tarahi (2021) confirms the relationship between persuasion knowledge in the sense of the PKM and information consumers' capacity to resist persuasion.

Accepting information as credible is a result of cognitive processing, which can take place analytically (e.g., searching for scientific articles and checking facts) or intuitively (e.g., trusting one's "guts feeling") (Pennycook, 2022; Petty & Cacciopo, 1986). Analytic processing is more laborious, therefore slower, and more likely to lead to an accurate discernment of fake vs. truthful news. Intuitive processing is less laborious, therefore faster, but often less accurate (Faragó et al., 2023; Pennycook, 2022).

While these effects are confirmed with adults, for the most part, fake news effects on children are not yet sufficiently researched. From the age of approximately six, children can perform inductive and deductive thinking, and thus form their own opinions and beliefs (Markovits, 2013). Biases like confirmation bias, which affects such beliefs, could also emerge around that age. Further effects like the mere exposure effect and the illusory truth effect should be challenged at a young age, while children are beginning to consume media, and are presumably not repeatedly exposed to fake news, yet.

### **Information literacy interventions**

From a mass communication research perspective, interventions against misinformation and manipulation through disinformation are typically classified in two broad categories: fact checking and inoculation (Lazer et al., 2018). While the former term may be self-explaining, the latter means confronting news consumers with fake news in a weaker form, example given, in computer game environments (Traberg et al., 2022), in order to immunize consumers to a misinformation threat (McGuire, 1961). Both fact checking and inoculation require and, in practice, comprise providing news consumers with various types of information in the framework of the PKM (Friestad & Wright, 1994). Fact checking mainly requires domain knowledge, the simplest type of knowledge being that a piece of news may be untruthful. Inoculation focuses on agent knowledge (Traberg et al., 2022). While the effects of both methods, especially in association with analytic reasoning (Faragó et al., 2023), have been empirically confirmed in many studies (e.g., Koch et al., 2023; Traberg et al., 2022), likely as result of intuitive processing, inoculation seems to induce generic

skepticism towards online news, rather than improving (analytic) discernment of truthful vs. fake news (Modirrousta-Galian & Higham, 2023). The latter effect would be desirable from a media education perspective.

An effective alternative approach can be found in Wineburg et al.'s (2022) lateral reading technique, an application of source credibility evaluation (Kiili et al., 2023) in which news consumers pay less attention to the news per se and search for "lateral" information about the news authors, their social and political activity, and their sponsors. In terms of the PKM, lateral reading focuses on providing news consumers with agent knowledge. Study participants considerably improved their ability to assess news credibility after being trained in lateral reading (Fendt et al., 2023; Wineburg et al., 2022). As lateral reading comprises active and concerted search for specific information, the analytic route likely contributes to this improvement.

These interventions have primarily been administered to adults (e.g., Fendt et al., 2023; Pérez-Escobar et al., 2021; Traberg et al., 2022; Wineburg et al., 2022), with only a few to adolescents, and even less to children. For instance, Nygren et al. (2021) conducted a fact checking intervention with 14 to 16-year-old pupils, after which participants could assess online news credibility more accurately. Extrapolating the findings to children requires researchers to consider human cognitive development. Whereas children develop a theory of mind from a very young age, and may also develop metacognition (as to understand how theory of mind contributes to persuasion), their persuasion knowledge may not be sufficient, they may not be aware of the agents behind misinformation (as to draw on theory of mind), or they may have insufficient topic knowledge. Resistance as an attitude against persuasion (e.g., against truth bias) usually develops later (Evans & Park, 2015; Markovits, 2013). In this vein, Castonguay (2022) found that disclosing the advertising intention in online sources (e.g., online videos) activates persuasion knowledge, whereas, for the least mature audience (5–12 years of age), such disclosure may not be sufficient. Similarly, Roberts et al. (2021) observed that warning children about inaccurate news content does not improve their news credibility assessment. Addressing this challenge, and notwithstanding the major research gap, some authors emphasize the importance for fake news interventions or media literacy education in elementary school (e.g., Corser et al., 2022; Dumitru, 2020; Loos et al., 2018; Nagel, 2022), but without delivering concrete intervention concepts.

## **Instructional design approaches supporting information literacy interventions**

As the above discussed examples show, interventions against fake news imply involving media consumers in complex activities that can require instructional approaches like problem-based learning (PBL; Scheibenzuber et al., 2021). PBL was proven to generally have a positive and large effect ( $d = .66$ ) on skill development (Dochy et al., 2003). Comparable effects were found with elementary school children (Heindl, 2019), which suggests that information literacy interventions for children may benefit from a problem-based design.

From the many instructional designs defined under the umbrella of PBL, inquiry-based learning (IBL) appears promising as its effects have been affirmed in many empirical studies (Lazonder & Harmsen, 2016). IBL aims to develop learners' problem-solving skills by conducting their own research similar to the scientific discovery process (Pedaste et al., 2015), which in turn requires them to argue about science questions, conduct experiments, draw conclusions, and explain their own ideas and how these ideas can be extended to different phenomena and contexts (Jerrim et al., 2020). Pedaste et al. (2015) identify five inquiry phases that can be performed in various order and extent depending on the specific learning environment: First, the subject is introduced, or a learning challenge is set (orientation). Second, a question is asked or a hypothesis is stated as a possible response to the challenge (conceptualization). Third, an exploration or experimentation may include process planning or data analysis (investigation). Fourth, a solution to the initial problem is created (conclusion). Fifth, the results discussion and the inquiry itself can be included in and connected with every other phase (discussion). These types of activities need to be combined with direct instruction, access to learning content, and contextual support (Suárez et al., 2017).

IBL success can be improved through technology (Pedaste et al., 2015). To create an IBL environment in this study, we used the tools Fakefinder and Fakefinder Kids designed by a German governmental broadcasting company (SWR, 2019). Fakefinder Kids was designed for elementary school children from the third grade upwards and introduces them to the topics of advertising, chain letters, and image manipulation. Fakefinder presents a chatroom in which a virtual friend asks questions about news samples, gives tips on how to assess them, and ultimately confirms or corrects the assessment made. In line with the limited research on

fostering children's information literacy, these tools were so far insufficiently evaluated regarding their effects on news credibility assessment accuracy and possible changes in the associated cognitive processing level.

## **Evaluating information literacy interventions**

The development of learning environments needs to go hand in hand with their evaluation. For the purpose of this pilot study, we applied two basic evaluation criteria. First, engaging children in any kind of intervention requires their acceptance. More specifically, attitudinal acceptance (e.g., perceiving the activity as "fun") and behavioral acceptance (i.e., carrying out instructional tasks) towards the training environment were deemed relevant to the intervention's success (e.g., Granić & Marangunić, 2019).

The second basic evaluation criterion was children's performance in evaluating the information. As stated above, the intervention aims at improving the discernment between real and fake news, rather than inducing generic skepticism towards news (Modirrousta-Galian & Higham, 2023). In other words, the intervention should decrease fake news credibility, while the credibility of true news should ideally remain unchanged. This ability may require moving the cognitive processing route from no processing to intuitive and, ultimately, to analytic processing (Fragó et al., 2023).

## **Research questions**

The primary research gap we address in this study is that insufficient research has been conducted on the causal relationship between information literacy training approaches, cognitive processing of online news, and the accuracy of credibility assessments. Even less research has been conducted with elementary school students (Queiroz De Jesus & Hubbard, 2021; Stanley & Lawson, 2020). Hence, we designed and conducted a fake news-focused information literacy training for elementary school students and examined the following research questions (RQs).

RQ1. To what extent do elementary school students accept the information literacy training focused on fake news, as indicated by their fun perception and the number of completed tasks?

RQ2. What is the effect of the information literacy training's problem-based design on the elementary

school students' ability to correctly assess online news credibility, as compared with direct instruction?

RQ3. What is the effect of the information literacy training's problem-based design on the elementary school students' cognitive route of online news credibility assessment, as compared with direct instruction?

Given the pilot character of the study, these RQs are stated to gain a first insight in the training's feasibility and acceptance, and to identify the largest training effects, if any.

## METHODOLOGY

### Research design

Notably, many of the existing studies on fake news interventions were built upon a pre-post design (e.g., Nygren et al., 2021), which does not support causal conclusions. Our study was built upon a mainly quantitative design including basic descriptive measures, a causal comparison, and, addressing RQ3, a quantitative content analysis.

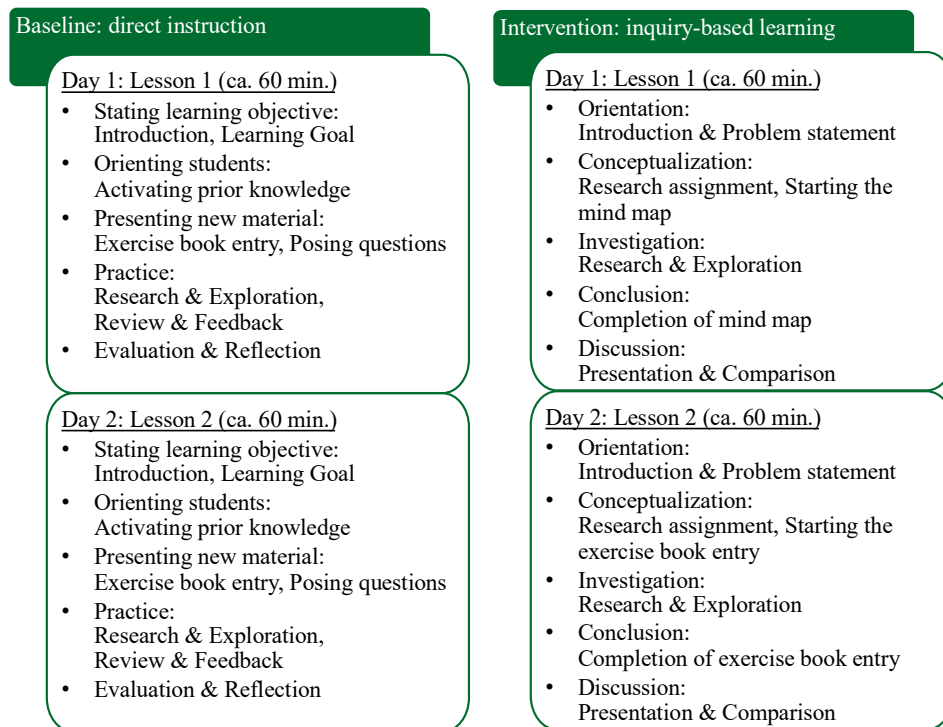


Figure 1. Comparison of the teaching units

The causal comparison aimed to assess the effects of the problem-based instructional design – specifically, inquiry-based learning – as an additional element to providing the same information via direct instruction. Therefore, we compared a group where the fake news-related contents were taught via direct instruction (baseline group) with a group in which the same content was learned through inquiry (intervention group), as depicted in Figure 1.

### Population and sample

For this pilot study, we deemed appropriate a convenience sample gathered as efficiently as possible.

In this sense, and in order to protect the potential participants, we chose older school classes from the elementary school where the first author worked. The sample size was chosen to be as small as possible while still having enough statistical power to detect differences between groups. According to G\*Power 3.1, in order to identify large effects of the size  $f = .50$  (partial  $\eta^2 = .20$ ) by means of repeated-measures ANOVA with an alpha error probability of .05 and power .80 in two groups, at two datapoints with a moderate correlation (.50) among repeated measures, a minimum sample size of 26 participants was required for between factors and 12 for within factors and within-between interaction.

Based on these considerations, the participants were 4<sup>th</sup> grade students from an elementary school with approx. 250 students at the periphery of a large city in southern Germany. After receiving approval from the university department's ethics committee and the school principal, the study involved 36 students (24 girls and 12 boys) in two grade 4 classes, aged around 10, from which  $N = 29$  ( $n_1 = 13$  comprised the reference group in one of the classes and  $n_2 = 16$  the treatment group in the other class) provided complete and valid data for the study.

### Intervention

The training aimed to improve participants' ability to assess online news as true or fake, as a result of improved cognitive information processing. Keeping in mind the PKM (Friestad & Wright, 1994), the learning materials included information on potential risks of Internet use in children's everyday lives, addressing phenomena like chain letters and hidden advertising in social networks, influencers, and picture and video manipulations, along with background information, personal consequences, and recommendations for avoiding related pitfalls.

The *intervention group* worked out and elaborated on this information in the framework of an IBL approach with the stages: orientation, conceptualization, investigation, conclusion, and discussion (Pedaste et al., 2015), as presented in Figure 1. The first lesson, which lasted about 60 minutes, began with gathering students' assumptions about possible dangers in their daily Internet use. The subject was introduced via the problematization of fake news and applying the problem to the living environment; subsequently, they worked out a research assignment for the lesson (orientation). The teacher started a mind map on the board, which the children continued self-directedly during the lesson (conceptualization). Students' assumptions made at the beginning were explored, systematically investigated, and verified at workstations (investigation), and the students created own mind maps in their exercise books (conclusion). The mind maps were presented and compared (discussion). In the second lesson one week later, lasting around 60 minutes again, the students made assumptions about how the knowledge they had gained on the first day could be applied to fake news (orientation). The teacher formulated a research assignment (conceptualization). In response, the students started learning at the workstations (investigation) and following created an exercise book

entry together on the board, which they eventually transferred to their notebooks and checked against their initial assumptions based on the mind map (conclusion). The training concluded with a summary and discussion of the new understandings and potential applications in students' everyday lives (discussion).

The training was based on self-directed and collaborative learning in small groups at various workstations in the classroom offering 7 tasks in total. Five stations supported 5 generic tasks: researching information online, creating methods to discover fake news and protect themselves, creating their own fake news, debunking fake news, and practicing lateral reading (McGrew & Byrne, 2020). Two further stations additionally included the tools Fakefinder Kids and the Fakefinder School. This interactive, game-based website features TikToks, chat histories, and YouTube videos, where students can identify image manipulation, chain letters, or advertising (SWR, 2019). The students were confronted with news from different virtual chat partners, had the possibility to check the source, and classified the news as true or fake. The decision could be made by source checking or by lateral reading, as the students had access to the internet at all times. Fakefinder provided task-specific feedback. Complementarily, the teacher gave feedback on learning progress and results. Decisions about the total number of worked out tasks, the depth of research, and the time spent on each task were left to the students.

Starting the first lesson, the teacher stated the learning goals of the lessons also addressing students' relevant background knowledge. He provided the students with new information and wrote an exercise book entry. The students solved Fakefinder (SWR, 2019) tasks in plenum and reflected on their new knowledge in a teacher-led conversation in class. The teacher gave feedback and initiated discussions on understanding issues. Concluding the lesson, students reflected again on the newly acquired knowledge and related this to their own media consumption. The second lesson was similarly structured, and included more advanced knowledge.

With the *baseline group*, the same information was taught following the principles of direct instruction (Slavin, 2018) as shown in Figure 1. Starting the lesson, the teacher stated the learning objectives, reviewed prerequisites, and presented new material. He asked questions to assess students' understanding before proceeding to the practical exercise. Subsequently, he reviewed the practice and gave feedback. Finally,

distributed practice and review were performed to ensure knowledge storing and recalling.

## Measures

In response to the research questions, students' *attitudinal acceptance* of online news literacy training was operationalized as students' perception of the training "being fun," a corresponding question being answered on a 4-point Likert scale. The *behavioral acceptance* was assessed as the number of tasks solved during the training.

Table 1. *Content analysis codes*

Codes	Description	Examples	
0	No processing	No answer	
1	Intuitive processing	Participants decide to what extent the news is credible based on "gut feeling" or hunch.	"I cannot imagine that."
2	Memory-based analytic processing	Participants analyze news based on previously acquired factual knowledge.	"Egypt is too warm for snow."
3	Investigative analytic processing	Participants actively search for information on message, author, or source during the training, and analyze the news based on the newly acquired knowledge.	"I found on the Internet that..."

The *ability to correctly assess online news credibility* (RQ2) was measured showing the students 8 examples of online news, from which 4 were truthful and 4 fake, and asking how credible they thought these were, on a Likert scale from 1 = not credible at all to 4 = entirely credible (Pennycook et al., 2020). The scale was reversed for the fake news examples, thus reflecting the distance between students' assessment and the actual news quality (1 = best assessment to 4 = worst assessment) and corresponding with the German school grading scale.

The news credibility scores were calculated as the sum of all items, taking values from 8 to 32, and separately of the true and fake items (assessing the true and fake news identification), with values from 4 to 16 each. As this variable was a formative construct, Cronbach's alpha was not deemed meaningful (Stadler et al., 2021); therefore, it was not calculated. The *cognitive route* (RQ3) (Faragó et al., 2023; Pennycook,

2022; Petty & Cacciopo, 1986) was assessed by asking the students to justify their news assessment. Students' answers were collected for a quantitative content analysis and then analyzed. Each student statement was seen as one unit of analysis. No answer was coded as 0, an intuitive answer as 1, a knowledge-based answer as 2, and an analytic answer as 3. An overview of the analysis codes is provided in Table 1. The corpus was first analyzed by the entire authors team (3 coders). Discrepancies were discussed refining the code book until consensus was reached. At about one fourth of the corpus, no more discrepancies occurred, after which the material was coded by the first author alone. The first three measures were regarded as interval scales, the last one as an ordinal scale.

## Procedure

The training was conducted face-to-face, and the measures were done as paper-and-pencil tests. Attitudinal and behavioral acceptance were measured at the end of the training; the ability to correctly assess online news credibility and the cognitive route were measured both at the beginning and at the end. The study procedure is depicted in Figure 2.

Besides generic descriptive statistics, RQ2 was answered by repeated measures ANOVA. The Kolmogorov-Smirnov test was not significant ( $D(29) = 0.091, p = 0.97$ ), indicating the news credibility scores followed a normal distribution. A Q-Q plot confirmed the normal distribution of the data. RQ3 involved ordinal data; therefore, it was answered using the Friedman and Kruskal-Wallis tests. The software used was IBM SPSS Statistics version 28.

## FINDINGS

### RQ1. Training acceptance

With respect to the training environment acceptance, 15 out of 16 inquiry-based and 12 out of 13 direct instruction learners reported they had fun, which suggested high attitudinal acceptance. A  $\chi^2$  test showed no significant difference between groups. The 7 tasks were solved 16, 12, 10, 13, 12, 14, and 4 times (Table 2), which indicated high behavioral acceptance. Again, the  $\chi^2$  test showed no significant difference between groups.

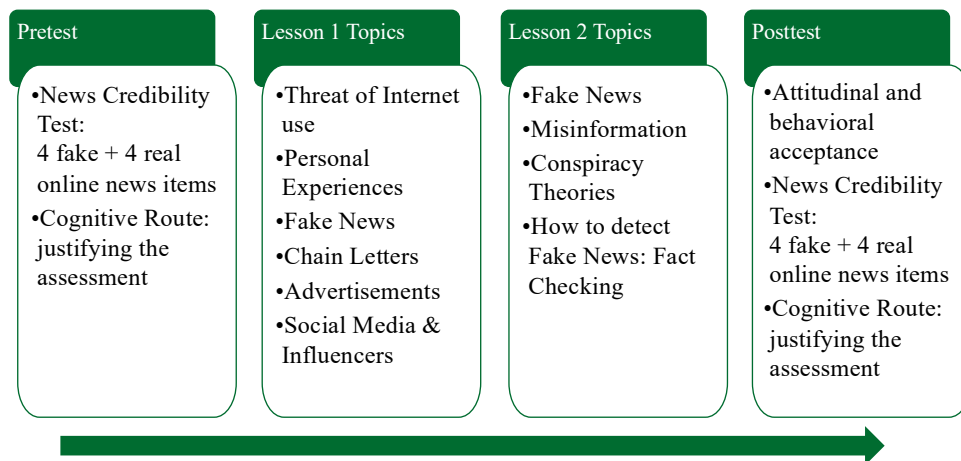


Figure 2. Study procedure

Table 2. Number of Completed Tasks in the Experimental Group

Task	1	2	3	4	5	6	7
Number of completions	16	12	10	13	12	14	4

### RQ2. News credibility test performance

With respect to the *within-subject effects*, participants' online news assessment improved from  $M = 2.32$  ( $SD = .27$ ) in the pretest to  $M = 1.76$  ( $SD = .41$ ) in the posttest. A repeated measures ANOVA indicated this improvement as statistically significant,  $F(2, 26) = 42.49$ ,  $p < .001$ ; partial  $\eta^2 = .61$  (large effect). The within-subject effects remained significant when fake and true online news were considered separately. For fake news, participants' online news assessment improved from  $M = 1.93$  ( $SD = .49$ ) in the pretest to  $M = 1.63$  ( $SD = .47$ ) in the posttest, with  $F(1, 27) = 9.11$ ,  $p = .005$ ; partial  $\eta^2 = .25$ . For true news, participants' online news assessment improved from  $M = 2.71$  ( $SD = .42$ ) in the pretest to  $M = 1.90$  ( $SD = .57$ ) in the posttest, with  $F(1, 27) = 37.55$ ,  $p < .001$ , partial  $\eta^2 < .001$ .

The *between-subject effects* were not significant,  $F(1, 27) = 1.36$ ,  $p = .25$ ; partial  $\eta^2 = .05$  for all online news;  $F(1, 27) = 3.17$ ,  $p = .09$ ; partial  $\eta^2 = .11$  for fake news; and  $F(1, 27) = .03$ ,  $p = .86$ ; partial  $\eta^2 = .001$  for true news. However, looking at the *interaction effects*, the inquiry-based learners improved their scores from  $M = 2.36$  ( $SD = .27$ ) in pretest to  $M = 1.63$  ( $SD = .43$ ) in posttest,  $\Delta M = .73$ , which was a stronger improvement than the direct instruction group with  $M = 2.27$  ( $SD = .28$ ) in pretest to  $M = 1.93$  ( $SD = .31$ ) in posttest,  $\Delta M =$

.34. This interaction effect was significant,  $F(1, 27) = 5.86$ ,  $p = .02$ ; partial  $\eta^2 = .18$  (large effect). The interaction effect remained significant for fake news identification, where the inquiry-based learners improved their scores from  $M = 1.98$  ( $SD = .50$ ) in pretest to  $M = 1.36$  ( $SD = .33$ ) in posttest,  $\Delta M = .62$ , whereas the direct instruction group rose from  $M = 1.87$  ( $SD = .28$ ) in pretest to  $M = 1.96$  ( $SD = .39$ ) in posttest,  $\Delta M = -.09$ .

Table 3. News credibility test performance (RQ2): descriptive statistics

	Instructional design	N	Datapoint	M	SD
All News	IBL	16	Pretest	2.36	0.27
			Posttest	1.63	0.43
	DI	13	Pretest	2.27	0.28
			Posttest	1.93	0.31
Total	29	Pretest	2.32	0.27	
			Posttest	1.76	0.41
True News	IBL	16	Pretest	2.73	0.39
			Posttest	1.89	0.67
	DI	13	Pretest	2.67	0.46
			Posttest	1.90	0.43
Total	29	Pretest	2.71	0.42	
			Posttest	1.90	0.57
Fake News	IBL	16	Pretest	1.98	0.50
			Posttest	1.36	0.33
	DI	13	Pretest	1.87	0.49
			Posttest	1.96	0.39
Total	29	Pretest	1.93	0.49	
			Posttest	1.63	0.47



Table 4. Overview of ANOVA results

		<i>F</i>	<i>p</i>	partial $\eta^2$
Within-subject effects	All News	$F(2, 26) = 42.49$	< .001	.61
	True News	$F(1, 27) = 37.55$	< .001	.001
	Fake News	$F(1, 27) = 9.11$	.005	.25
Between-subject effects	All News	$F(1, 27) = 1.36$	.25	.05
	True News	$F(1, 27) = .03$	.86	.001
	Fake News	$F(1, 27) = 3.17$	.09	.11
Interaction effects datapoint* treatment	All News	$F(1, 27) = 5.86$	.02	.18
	True News	$F(1, 27) = .08$	.78	.003
	Fake News	$F(1, 27) = 16.95$	< .001	.39

The interaction effect related to fake news was significant,  $F(1, 27) = 16.95, p < .001$ ; partial  $\eta^2 = .39$  (large effect). For true news identification, the inquiry-based learners improved their scores from  $M = 2.73$  ( $SD = .39$ ) in pretest to  $M = 1.89$  ( $SD = .67$ ) in posttest,  $\Delta M = .84$ ; the direct instruction group improved from  $M = 2.67$  ( $SD = .46$ ) in pretest to  $M = 1.90$  ( $SD = .43$ ) in posttest,  $\Delta M = .77$ . This interaction effect was not significant,  $F(1, 27) = .08, p = .78$ ; partial  $\eta^2 = .003$ . A results overview is provided in Tables 3 and 4.

### RQ3. Cognitive processing route

Related to the *within-subject effects*, the mean rank of the cognitive route score increased from 1.20 before, to 1.80 after the training. The increase was statistically significant: a Friedman test resulted in  $\chi^2(1) = 12.46, p < .001$ , with effect sizes  $r = .55$  (large effect) and Kendall's  $W = .42$  (moderate to large effect). These increases remained significant when fake and true online news were considered separately. For fake news, the cognitive route scores increased from 1.28 before, to 1.72 after the training, with  $\chi^2(1) = 6.76, p = .009$ , effect sizes  $r = .46$  (large effect) and Kendall's  $W = .23$  (small to moderate effect). For true news, the cognitive route scores increased from 1.22 before, to 1.78 after the training, with  $\chi^2(1) = 10.70, p = .001$ , effect sizes  $r = .59$  (large effect), Kendall's  $W = .36$  (moderate effect).

With respect to the *between-subject effects*, the mean rank of the cognitive route scores increased from 1.12 for direct instruction to 1.93 for inquiry-based learning. A Kruskal-Wallis H test indicated this difference as statistically significant,  $\chi^2(1) = 6.40, p = .01$ , effect size  $\eta^2 = .22$  (large effect). The increases remained sizes is provided in Table 5.

significant when true and fake news were considered separately. For fake news, the mean rank of the cognitive route scores increased from 1.18 for direct instruction to 1.87 for inquiry-based learning;  $\chi^2(1) = 4.70, p = .03$ , effect size  $\eta^2 = .16$  (large effect). For true news, the mean rank of the cognitive route scores increased from 1.16 for direct instruction to 1.89 for inquiry-based learning;  $\chi^2(1) = 5.35, p = .02$ , effect size  $\eta^2 = .18$  (large effect).

### Sensitivity analysis

Given the small sample size, we finally conducted a sensitivity analysis aimed to determine the smallest effects possible to identify in the study. For the *F* tests category, particularly repeated measures ANOVA, with  $\alpha$  error probability of .05, power  $(1 - \beta) = .80$ , 2 groups with a total of  $N = 29$  participants, and 2 datapoints, the smallest detectable effect was  $f = .27$  (partial  $\eta^2 = .07$ ) for within-subject and interaction effects. For between-subject effects, the smallest detectable effect was  $f = .47$  (partial  $\eta^2 = .17$ ). For generic  $\chi^2$  tests, also representing the Friedman and Kruskal-Wallis tests employed above, with  $\alpha$  error probability of .05, power  $(1 - \beta) = .80$ , and  $df = 1$ , the critical  $\chi^2$  value was 3.84. An overview of the sensitivity analysis and comparison between required and found effect.

## DISCUSSION

In this study, we aimed to design, conduct, and evaluate an information literacy training based on inquiry learning for elementary school children. Keeping in mind that, for this age group, special participant and data protection regulations apply, we chose to first conduct a pilot study with a small number of participants, efficiently gathered, on which we could gain a first insight into the training's feasibility and acceptance, and to roughly identify the largest training effects.

A sensitivity analysis showed that all effects we found, excepting the non-significant ANOVA between-subject effects, were larger than the required minimum. As such, we summarize and discuss the information literacy design and the empirical findings associated with it below.

Table 5. Overview of sensitivity analysis and power adequacy

RQ	Investigated effect	Test type	Found effect size	Required minimum effect size	Adequate power
RQ2 (News credibility test performance)	Within-subject	ANOVA	partial $\eta^2 = .61$	partial $\eta^2 = .07$	Yes
	Between-subject	ANOVA	partial $\eta^2 = .05, n.s.$	partial $\eta^2 = .18$	No
	Interaction	ANOVA	partial $\eta^2 = .18$	partial $\eta^2 = .07$	Yes
RQ3 (Cognitive route)	Within-subject	Friedman	$\chi^2(1) = 12.46$	critical $\chi^2 = 3.84$	Yes
	Between-subject	Kruskal-Wallis	$\chi^2(1) = 6.40$	critical $\chi^2 = 3.84$	Yes

Note. Sensitivity analysis settings:  $\alpha$  error probability = .05, power  $(1 - \beta) = .80$ , 2 groups,  $N = 29$ ,  $df = 1$ , 2 datapoints

### RQ1. Training acceptance

The participants accepted the training to a high degree, both in the sense of attitudinal and of behavioral acceptance. There was no significant difference between the experimental groups in terms of perceived “fun” or of the number of solved tasks. This is consistent with many studies showing children’s affinity with many aspects related to the Internet (e.g., Hooft Graafland, 2018). As for the acceptance of IBL, our findings are consistent with studies showing a positive relationship between children’s IBL and their curiosity (e.g., van Schijndel et al., 2018). For the purpose of this study, the high acceptance of the pilot training represents a fulfilled prerequisite for further research and development.

### RQ2. News credibility test performance

The online news literacy training was associated with a significant and large pre-post increase in participants’ test performance. On the other hand, the comparison between the IBL and the direct instruction group could not identify any direct effect, and the sensitivity analysis suggested that this could be due to the small sample, indicating there might be direct effects under the sensitivity threshold of part.  $\eta^2 = .18$ . Nevertheless, there was a significant and large interaction effect (part.  $\eta^2 = .18$ ) between measurement time and treatment, such that the pre-post difference was larger for the IBL group than for the reference group. In other words, and given that both experimental groups received the same information on how to recognize misinformation, the IBL format appeared to have a large effect on participants’ online news literacy development.

This is consistent with previous studies showing positive effects of PBL in general (Dochy et al., 2003; Hattie, 2009), IBL in particular (Heindl, 2019; Jerrim et al., 2020; Pedaste et al., 2015), and online news literacy training (e.g., Scheibenzuber et al., 2021) on participants

of various ages. Whereas PBL and IBL studies included elementary school students, too, little was known so far about the effects of online news literacy training on this particular age group (Queiroz De Jesus & Hubbard, 2021; Stanley & Lawson, 2020). Our study thus contributes to closing this gap in research.

### RQ3. Cognitive processing route

In examining the efficacy of our training, we also aimed to explain this effect by participants’ cognitive processing route (Petty & Cacioppo, 1986). Indeed, the training was associated with a significant and large pre-post shift of participants’ explanations towards analytic reasoning and active search of information supporting their online news evaluation. There was also a significant difference between experimental groups, suggesting a large effect of the training on participants’ cognitive processing of online news.

### Consequences, limitations and future research

As the inquiry-based online news literacy training (Pedaste et al., 2015) yielded encouraging results in regard to its effectiveness, this study’s consequence for educational practice is clear: Implementing such training on a larger scale may be an appropriate way to address the challenges of misinformation at an early age. To achieve this, elementary school teachers should be trained, in turn, to develop corresponding teaching skills related to both IBL and media literacy.

Whereas the identified effects are in line with previous research (Faragó et al., 2023; Schwarz & Jalbert, 2021), the findings are inconclusive with respect to the causal relationship between the intervention, the cognitive processing route, and participants’ online news discernment. A possible mediation effect of the cognitive route should be examined in future research.

A methodological limitation worth mentioning was the small sample size. While the study brought adequate power with respect to most effects we tested, smaller

effects may have been blurred, for example, the marginal between-subject effects of the inquiry-based training ( $p = .09$ ; partial  $\eta^2 = .11$  for fake news identification). To address this limitation, in future research the information competence training should be conducted with a larger number of participants. Moreover, the stability over time of the training effect also remains to be investigated. In future studies, a later datapoint could be added for a delayed post-test. The employed acceptance instruments were very simple and not sufficiently validated for our participants' age. In future studies, we will concentrate on overcoming methodological issues and increasing the generalizability of our findings.

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#### REFERENCES

- Carter, C., Steemers, J., & Davies, M. M. (2021). Why children's news matters: The case of CBBC Newsround in the UK. *Communications*, *46*(3), 352–372. <https://doi.org/10.1515/commun-2021-0048>
- Castonguay, J. (2022). Influencers' disclosures of advertising and responses from youth with varying levels of theory of mind. *Journal of Current Issues & Research in Advertising*, *43*(3), 237–255. <https://doi.org/10.1080/10641734.2021.1973928>
- Corser, K., Dezuanni, M., & Notley, T. (2022). How news media literacy is taught in Australian classrooms. *Australian Educational Researcher*, *49*(4), 761–777. <https://doi.org/10.1007/s13384-021-00457-5>
- Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning and Instruction*, *13*(5), 533–568. [https://doi.org/10.1016/S0959-4752\(02\)00025-7](https://doi.org/10.1016/S0959-4752(02)00025-7)
- Dumitru, E. A. (2020). Testing children and adolescents' ability to identify fake news: A combined design of quasi-experiment and group discussions. *Societies*, *10*(3), 71. <https://doi.org/10.3390/soc10030071>
- Eisend, M., & Tarrahi, F. (2022). Persuasion knowledge in the marketplace: A meta-analysis. *Journal of Consumer Psychology*, *32*(1), 3–22. <https://doi.org/10.1002/jcpy.1258>
- Evans, N. J., & Park, D. (2015). Rethinking the persuasion knowledge model: Schematic antecedents and associative outcomes of persuasion knowledge activation for covert advertising. *Journal of Current Issues & Research in Advertising*, *36*(2), 157–176. <https://doi.org/10.1080/10641734.2015.1023873>
- Faragó, L., Krekó, P., & Orosz, G. (2023). Hungarian, lazy, and biased: The role of analytic thinking and partisanship in fake news discernment on a Hungarian representative sample. *Scientific Reports*, *13*(1), 1–9. <https://doi.org/10.1038/s41598-022-26724-8>
- Feierabend, S., Plankenhorn, T., & Rathgeb, T. (2021). *KIM-Studie 2020: Kindheit, Internet, Medien [Kim Study 2020: Children, Internet, Media]*. Medienpädagogischer Forschungsverbund Südwest.
- Fendt, M., Nistor, N., Scheibenzuber, C., & Artmann, B. (2023) Lateral reading against misinformation: Effects of a scalable training based on cognitive apprenticeship. SSRN, Preprint 4347464. <https://doi.org/10.2139/ssrn.4347464>
- Friestad, M., & Wright, P. (1994). The persuasion knowledge model: How people cope with persuasion attempts. *Journal of Consumer Research*, *21*(1), 1–31. <https://doi.org/10.1086/209380>
- Granić, A., & Marangunić, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology*, *50*(5), 2572–2593. <https://doi.org/10.1111/bjet.12864>
- Hasher, L., Goldstein, D., & Toppino, T. (1977). Frequency and the conference of referential validity. *Journal of Verbal Learning and Verbal Behavior*, *16*(1), 107–112. [https://doi.org/10.1016/S0022-5371\(77\)80012-1](https://doi.org/10.1016/S0022-5371(77)80012-1)
- Hattie, J. (2009). *Visible learning. A synthesis of over 800 meta-analyses relating to achievement*. Routledge.
- Heindl, M. (2019). Inquiry-based learning and the prerequisite for its use in science at school: A meta-analysis. *Journal of Pedagogical Research*, *3*(2), 52–61. <http://doi.org/10.33902/JPR.2019254160>
- Hoof Graafland, J. (2018). New technologies and 21st century children: Recent trends and outcomes. *OECD Education Working Papers*, 179. OECD Publishing. <https://doi.org/10.1787/e071a505-en>
- Jerrim, J., Oliver, M., & Sims, S. (2020). The relationship between inquiry-based teaching and students' achievement. New evidence from a longitudinal PISA study in England. *Learning and*

- Instruction*, 80, Article 101310.  
<https://doi.org/10.1016/j.learninstruc.2020.101310>
- Kiili, C., Rääkkönen, E., Bråten, I., Strømsø, H. I., & Hagerman, M. S. (2023). Examining the structure of credibility evaluation when sixth graders read online texts. *Journal of Computer Assisted Learning*.  
<https://doi.org/10.1111/jcal.12779>
- Koch, T. K., Frischlich, L., & Lermer, E. (2023). Effects of fact-checking warning labels and social endorsement cues on climate change fake news credibility and engagement on social media. *Journal of Applied Social Psychology*.  
<https://doi.org/10.1111/jasp.12959>
- Lazer, D. M. J., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., Zittrain, J. L. (2018). The science of fake news. *Science*, 359(6380), 1094–1096.  
<https://doi.org/10.1126/science.aao2998>
- Lazonder, A. W., & Harmsen, R. (2016). Meta-analysis of inquiry-based learning: Effects of guidance. *Review of Educational Research*, 86(3), 681–718.  
<https://doi.org/10.3102/0034654315627366>
- Loos, E., Ivan, L., & Leu, D. (2018). “Save The Pacific Northwest Tree Octopus”: a hoax revisited. Or: how vulnerable are school children to Fake News? *Information and Learning Science*.  
<http://doi.org/10.1108/ILS-04-2018-0031>
- Maftai, A., Holman, A. C., & Merlici, I. A. (2022). Using fake news as means of cyber-bullying: The link with compulsive internet use and online moral disengagement. *Computers in Human Behavior*, 127, 107032.  
<https://doi.org/10.1016/j.chb.2021.107032>
- Markovits, H. (2013). The development of abstract conditional reasoning. In P. Barrouillet & C. Gauffroy (Eds.), *The development of thinking and reasoning* (pp. 83–104). Psychology Press.  
<https://doi.org/10.4324/9780203068748-11>
- McGrew, S., & Byrne, V. L. (2020). Who is behind this? Preparing high school students to evaluate online content. *Journal of Research on Technology in Education*, 53(4), 457–475.  
<https://doi.org/10.1080/15391523.2020.1795956>
- McGuire, W. J. (1961). Resistance to persuasion conferred by active and passive prior refutation of the same and alternative counterarguments. *Journal of Abnormal and Social Psychology*, 63(2), 326–332. <https://doi.org/10.1037/h0048344>
- Modirrousta-Galian, A., & Higham, P. A. (2023). Gamified inoculation interventions do not improve discrimination between true and fake news: Reanalyzing existing research with receiver operating characteristic analysis. *Journal of Experimental Psychology: General*. Advance online publication. <https://doi.org/10.1037/xge0001395>
- Nagel, T. W. (2022). Measuring fake news acumen using a news media literacy instrument. *Journal of Media Literacy Education*, 14(1), 29–42.  
<https://doi.org/10.23860/JMLE-2022-14-1-3>
- Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology*, 2(2), 175–220.  
<https://doi.org/10.1037/1089-2680.2.2.175>
- Nygren, T., Guath, M., Axelsson, C. A. W., & Fraumeigs, D. (2021). Combatting visual fake news with a professional fact-checking tool in education in France, Romania, Spain and Sweden. *Information*, 12(5), 201.  
<https://doi.org/10.3390/info12050201>
- Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., Monoli C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, 14, 47–61.  
<http://doi.org/10.1016/j.edurev.2015.02.003>
- Pennycook, G. (2022). A framework for understanding reasoning errors: From fake news to climate change and beyond. *Advances in Experimental Social Psychology*, 67, 131–208.  
<https://doi.org/10.1016/bs.aesp.2022.11.003>
- Pennycook, G., McPhetres, J., Zhang, Y., Lu, J. G., & Rand, D. G. (2020). Fighting COVID-19 misinformation on social media: Experimental evidence for a scalable accuracy-nudge intervention. *Psychological Science*, 31(7), 770–780.  
<https://doi.org/10.1177/0956797620939054>
- Pérez-Escolar, M., Ordóñez-Olmedo, E., & Alcaide-Pulido, P. (2021). Fact-checking skills and project-based learning about infodemic and disinformation. *Thinking Skills and Creativity*, 41, 100887.  
<https://doi.org/10.1016/j.tsc.2021.100887>
- Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. *Advances in Experimental Social Psychology*, 19, 123–205.
- Queiroz De Jesus, I., & Hubbard, J. (2021). Media literacy for elementary education students: Inquiry into fake news. *Social Studies*, 112(3), 136–145.  
<https://doi.org/10.1080/00377996.2020.1841717>
- Roberts, K. P., Wood, K. R., & Wylie, B. E. (2021). Children’s ability to edit their memories when learning about the environment from credible and noncredible websites. *Cognitive Research*:

- Principles and Implications*, 6(1), 1–18.  
<https://doi.org/10.1186/s41235-021-00305-1>
- Schwarz, N., & Jalbert, M. (2020). When (fake) news feels true: Intuitions of truth and the acceptance and correction of misinformation. In R. Greifeneder, M. E. Jaffé, E. J. Newman, & N. Schwarz (Eds.), *The psychology of fake news. Accepting, sharing, and correcting misinformation* (pp. 73–89). Routledge.
- Scheibenzuber, C., Hofer, S., & Nistor, N. (2021). Designing for fake news literacy training: A problem-based undergraduate online-course. *Computers in Human Behavior*, 121, 106796.  
<https://doi.org/10.1016/j.chb.2021.106796>
- Slavin, R. E. (2018). *Educational psychology: Theory and practice* (12th Edition). Pearson.
- Stadler, M., Sailer, M., & Fischer, F. (2021). Knowledge as a formative construct: A good alpha is not always better. *New Ideas in Psychology*, 60, 100832.  
<https://doi.org/10.1016/j.newideapsych.2020.100832>
- Stanley, S. L., & Lawson, C. (2020). The effects of an advertising-based intervention on critical thinking and media literacy in third and fourth graders. *Journal of Media Literacy Education*, 12(1), 1–12.  
<https://doi.org/10.23860/JMLE-2020-12-1-1>
- Suárez Á., Specht M., Prinsen F., Kalz M., & Ternier S. (2017). A review of the types of mobile activities in mobile inquiry-based learning. *Computers & Education*, 118, 38–55.  
<https://doi.org/10.1016/j.compedu.2017.11.004>
- SWR, (2019). SWR Fakefinder – Für Kids, für Jugendliche, für dich [For Kids, for Youngsters, for You]  
<https://www.swr.de/unternehmen/medienkompetenz/fakefinder-100.html>
- Traberg, C. S., Roozenbeek, J., & van der Linden, S. (2022). Psychological inoculation against misinformation: Current evidence and future directions. *Annals of the American Academy of Political and Social Science*, 700(1), 136–151.  
<https://doi.org/10.1177/00027162221087936>
- van Schijndel, T. J., Jansen, B. R., & Raijmakers, M. E. (2018). Do individual differences in children’s curiosity relate to their inquiry-based learning? *International Journal of Science Education*, 40(9), 996–1015.  
<https://doi.org/10.1080/09500693.2018.1460772>
- Wineburg, S., Breakstone, J., McGrew, S., Smith, M. D., & Ortega, T. (2022). Lateral reading on the open Internet: A district-wide field study in high school government classes. *Journal of Educational Psychology*, 114(5), 893–909.  
<https://doi.org/10.1037/edu0000740>
- Zajonc, R. B. (1968). Attitudinal effects: Mere exposure. *Journal of Personality and Social Psychology Monographs*, 9(2), 1–27.  
<https://psycnet.apa.org/doi/10.1037/h0025848>