



FROM TECHNOLOGY USE TO PEDAGOGICAL AWARENESS: DEVELOPMENT AND VALIDATION OF A WEB 2.0 AWARENESS SCALE

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Abstract: This study developed and validated a comprehensive and psychometrically sound Web 2.0 Awareness Test for science teachers. A total of 370 in-service science teachers participated in the quantitative survey. We created the initial 37-item pool (28 positively and 9 negatively worded items) based on systematic expert consultation to ensure strong content validity. We analyzed the data using IBM SPSS Statistics for exploratory factor analysis (EFA) and reliability testing, and IBM SPSS AMOS for confirmatory factor analysis (CFA). Additionally, we performed measurement invariance analyses across relevant demographic groups using Jamovi to assess the stability of the factor structure. Content validity was established through expert review, while EFA, CFA, and measurement invariance results supported construct validity. After item refinement, the final scale included 31 items across two dimensions, accounting for 58.34% of the total variance. Internal consistency coefficients (Cronbach's alpha and composite reliability) exceeded .70 for both the overall scale and its subdimensions, indicating good reliability. The validated instrument offers a reliable, empirically based tool for assessing science teachers' awareness of Web 2.0 technologies. It provides practical utility for evaluating both teachers' and students' digital awareness in modern educational settings.

Keywords: Teacher professional development, Evaluation methodologies, Scale development

1. Introduction

1.1. Problem Statement

Constructivist learning theory posits that learners actively construct their knowledge through experiences, interactions, and reflection, rather than passively receiving information (Glaserfeld, 1996; Matthews, 2002; Zajda, 2021). Science education, in particular, is closely aligned with constructivist principles, as it emphasizes inquiry-based learning, problem solving, and the active construction of scientific concepts (Akuma & Callaghan, 2019). In this context, science teachers play a crucial role in designing learning environments that foster exploration, collaboration, and conceptual understanding by integrating digital technologies (Chen et al., 2025; Lederman & Niess, 2000).

Web 2.0 tools provide science teachers with opportunities to enrich instruction through interactive simulations, collaborative knowledge construction, data sharing, and reflective discussion (Gu & Belland, 2015; Sadaf et al., 2015). These tools are considered especially valuable in science classrooms, where abstract concepts, scientific processes, and real-world problem contexts can be supported through visualization and collaboration (Hew & Cheung, 2013). Despite this potential, research indicates that science teachers often struggle to integrate Web 2.0 tools effectively into their instructional practices (Hao & Lee, 2015).

A key issue contributing to this challenge is the limited awareness among science teachers of Web 2.0 tools and their pedagogical benefits, which hinders their ability to identify and use these technologies effectively in instructional practice (Maulet et al., 2024; Ramos-Rodríguez et al., 2021). Awareness encompasses more than technical skills; it involves teachers' recognition, understanding, and

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pedagogical stance toward these tools in science education (Caena & Redecker, 2019). The current literature predominantly focuses on technological competence, attitudes, or self-efficacy, rather than recognizing awareness as a separate construct (Aksoy, 2024; Atalmış & Şimşek, 2022; Cakir et al., 2015; Yıldırım & Akkuş, 2020). Consequently, the technical capabilities of science teachers are frequently assessed, whereas their conceptualization and interpretation of the pedagogical significance of Web 2.0 tools in science education are inadequately explored.

Several studies have established awareness or usage scores that focus exclusively on student populations (Abusamra & Triwiyanto, 2023; Khowaja & Fatima, 2020), limiting their value for science teachers, whose instructional decisions directly impact student learning. Other research has explored the integration of Web 2.0 into scientific and mathematical contexts, but has not presented a standardized instrument to assess science instructors' awareness (Nayiroglu & Tutak, 2023). Thus, a constructivist-based, valid, and reliable measure to assess science teachers' understanding of Web 2.0 is lacking. This lack prevents the systematic identification of science teachers' levels of awareness and the implementation of professional development efforts tailored to scientific education (Kale & Goh, 2014). Why Web 2.0 integration in science classrooms is often superficial is unclear without a discipline-specific measurement tool (Ertmer et al., 2012). The primary issue addressed in this study is the lack of a psychometrically sound instrument to assess science instructors' awareness of Web 2.0 within a constructivist scientific education paradigm.

1.2. Rationale of the Study

Science teachers' awareness of Web 2.0 tools is essential for effective technology integration in inquiry-based and constructivist science learning environments (Bell et al., 2010). While technological competence indicates teachers' ability to use digital tools, awareness reflects their understanding of when, why, and how these tools can be pedagogically applied to support scientific inquiry, conceptual change, and collaborative knowledge building (Bell et al., 2010; Ertmer et al., 2012; Koehler & Mishra, 2009; Mishra & Koehler, 2006). This difference is especially important in science education, where successful learning depends on matching digital tools with the epistemic practices of science (Kale & Goh, 2014; Şimşek & Ateş, 2022; Teo et al., 2018).

Empirical studies consistently demonstrate that the effective use of Web 2.0 tools enhances student motivation, engagement, and interaction in science learning contexts (Caliskan et al., 2019; Uysal & Çaycı, 2022). Conversely, insufficient awareness among science teachers may lead to the ineffective or inappropriate use of these tools, which can negatively affect students' scientific reasoning skills and their development of digital literacy (Hao & Lee, 2015; Petko, 2012). Determining science teachers' levels of awareness is therefore essential for ensuring the pedagogically sound and sustainable integration of technology (Čipková et al., 2024).

The present study is justified by its potential contributions to science education research and practice. Theoretically, it addresses a significant gap by conceptualizing Web 2.0 awareness as a multidimensional construct encompassing cognitive, affective, and behavioral dimensions in the context of science teaching (Martin et al., 2025). Methodologically, the study aims to develop a valid and reliable measurement tool tailored explicitly to science teachers, thereby enabling more precise empirical investigations (Boateng et al., 2018). In practice, the scale will support science teachers in reflecting on their awareness levels, assist teacher educators and administrators in designing discipline-specific professional development programs, and inform policymakers seeking to strengthen digital transformation in science education (Amemasor et al., 2025; Asim et al., 2022).

By retaining established theoretical foundations and previously validated references, while explicitly foregrounding science teachers as the focal group, this study seeks to contribute robust and context-sensitive evidence to the international literature on the integration of educational technology in science education (Harris et al., 2009; Osborne & Dillon, 2010; Tondeur et al., 2017). Ultimately, developing a constructivist-based Web 2.0 awareness scale for science teachers is expected to enhance pedagogical decision-making and improve the quality of learning experiences in science classrooms (Bell et al., 2010; Scherer et al., 2020).

2. Method

2.1. Research Design

The study used a survey design with a quantitative research method. A survey is a design that aims to reveal the characteristics of a sample group, such as interests, attitudes, perceptions, opinions, and abilities (Fraenkel et al., 2023). Accordingly, the study employed this design to develop a valid and reliable measurement tool to objectively assess teachers' awareness of the use of Web 2.0 tools in education.

2.2. Population and Sample

This study employed simple random sampling to select participants. Simple random sampling minimizes bias and increases the sample's representativeness (Creswell & Creswell, 2018). The study sample consisted of 370 teachers in Kayseri province who were familiar with and used web tools. Tenfold the number of participants compared to the 37 items in the draft scale were engaged, constituting 10% of the available population (Pallant, 2016).

2.3. Content Validity

Content validity offers insight into how well a measurement tool's content accurately reflects the behaviors or qualities it is designed to assess (Finch, 2020). The present study created an item pool based on expert judgments to ensure the content validity of the draft scale (Table 1). This study aims to develop a five-point Likert-type scale as a data-collection tool to assess teachers' awareness of the use of Web 2.0 resources in education. The draft version of the scale includes 37 items: 28 positive and nine negative. Some draft scale elements were directly taken from existing literature (Table 1). The authors reorganized the draft scale items based on feedback from educational specialists' assessments. Two science education specialists, one Turkish education specialist, and one measurement and evaluation expert approved the revised draft scale items. The results section (Table 2) presents the outcomes of the content validity studies.

2.4. Construct Validity

Construct validity refers to a validity assessment that evaluates the degree to which a measurement instrument consistently encompasses a construct (Anastasi & Urbina, 1997). The current study incorporated an equal quantity of items for each dimension in the draft scale. Exploratory factor analyses (EFA), confirmatory factor analyses (CFA), and measurement invariance studies were used to verify construct validity. The EFA results were intended to determine the scale's structure and size. The scale's factor structure was further evaluated using CFA. CFA is used to assess the fit between the specified factor structure and the data, and model fit indices should fall within acceptable thresholds. The analyses confirm the scale's construct validity when the specified ranges are considered (Freund & Wilson, 2003).

2.5. Measurement Invariance

Measurement invariance refers to the uniformity of a scale's characteristics across multiple groups. When employing a scale in heterogeneous groups, it is essential to assess its performance across subgroups and ensure the results can be interpreted impartially. Evidence of measurement invariance serves as a significant source of validity evidence for the scale (Meredith, 1993; Vandenberg & Lance, 2000). Measurement invariance is assessed by evaluating four distinct hypotheses: structural, metric, scalar, and rigorous invariance (Meredith, 1993). Obtaining evidence of structural invariance at the fundamental level indicates that the measurement tool's items measure the same psychological construct across all populations. Metric invariance is defined as the equality in regression slopes (i.e., factor loadings) of the items constituting the measurement instrument across different groups. Scalar invariance indicates that items possessing identical values on the latent construct correspond equally to the values of the observable variable across both groups. Strict invariance evaluates the claim that error terms are consistent across comparison groups (Steenkamp & Baumgartner, 1998).

2.6. Reliability

Reliability is the degree to which participants respond consistently to scale items (George & Mallery, 2009). Additionally, item-specific factor loadings were evaluated, and a reliability index was incorporated into the process alongside Cronbach's Alpha. For the scores obtained from the scale to be considered reliable, the reliability analysis results were expected to exceed .70 (Pallant, 2016).

2.7. Data Collection Process

Before implementing the draft scale, the first researcher submitted an application to the ethics committee and obtained formal approval (Approval No. 240). Then, the third researcher transferred the draft scale to Google Forms. All authors sent links to the pre-service teachers. In the process-based, voluntary participation, the authors required that no item on the draft scale be left blank and that all items be marked. The study sample comprised 370 participants recruited over a 3-month data-collection period.

2.8. Data Analysis

The second researcher transferred the raw data into SPSS 27. The authors conducted EFA and reliability analyses in SPSS 27, CFA in AMOS 22, and measurement invariance analyses in Jamovi 2.4. Nine items on the scale (11, 14, 18, 21, 26, 27, 29, 30, 31) were reverse-coded. The study employed an item pool and expert review for content validity, and conducted EFA, CFA, and measurement invariance analyses to assess construct validity. The researchers also checked whether the items were usually distributed. In this scale development study, the data collection tool and data analysis processes are detailed in the findings.

3. Results

3.1. Item Pool and Expert Examination

Table 1 shows the item pool derived from the literature created during the early stage of scale development. A detailed review of previous research on Web 2.0 tools, technology integration, and digital literacy resulted in 178 items from various sources. These sources included both national and international studies focused on educational technology, teacher skills, and digital literacy. After an initial review, 24 items were selected from the literature to form the preliminary item pool. The distribution of items across sources indicates that the scale development was grounded in a broad and diverse theoretical foundation, ensuring that key aspects of Web 2.0 knowledge were well represented prior to expert evaluation.

Table 1. *Literature-based item pool*

Sources	Item Pool	Items Received
Arslan & Gorgulu Ari, 2021	27	6
Ertmer et al., 2012; Hew & Cheung, 2013	30	3
Wright, 2017	30	3
Gikandi et al., 2011; Teng & Wang, 2021; Tondeur et al., 2018	10	3
Timur et al., 2020	9	4
Bilgiç Kaşıkçı et al., 2023	28	1
Ertmer et al., 2012; Hew & Cheung, 2013; Kaplan & Haenlein, 2010; Tim, 2005	7	4
Total	178	24

Table 2 shows how to revise draft scale items based on expert analysis. The table lists item content, literature sources, and leading questions or assertions. Cognitive, affective, and psychomotor characteristics were employed to understand awareness of Web 2.0. Along with literature-derived items, scientific education specialists proposed new items to ensure construct validity and contextual

relevance. Expert input refined item phrasing, eliminated ambiguity, and expanded the scale's breadth, resulting in a 37-item draft version used for validity and reliability tests.

Table 2. *Editing the items in line with expert opinions*

Item	Item Content in the Draft Scale	Sources	Questions/Items Used
Cognitive Dimension			
1	When I think of Web 2.0 tools, I think of social media.	Kaplan & Haenlein, 2010; Timur et al., 2020	We wrote this item based on the questions 'What do you think of when you think of technology?' and 'What do Web 2.0 tools mean?'
2	When I think of Web 2.0 tools, I think of the Internet.	Tim, 2005; Timur et al., 2020.	We wrote this item based on your thoughts on technology and what Web 2.0 tools mean.
3	I can give examples of Web 2.0 tools.	Arslan & Görgülü Arı, 2021; Bilgiç Kaşıkçı et al., 2023	I can give examples of Web 2.0 tools.
4	I know at which stage of the course Web 2.0 tools will be used.	Tondeur et al., 2018	We wrote the item using the question, 'At which stage of the course do you think Web 2.0 tools should be used? Why?'
5	I can use Web 2.0 tools to make assessments in the course.	Gikandi et al., 2011	We wrote the item based on the question, 'For what purposes do you use Web 2.0 tools?'
6	I can use Web 2.0 tools to attract attention in class.	Teng & Wang, 2021	We wrote the item in response to the question, 'For what purposes do you use Web 2.0 tools?'
7	I can utilize Web 2.0 tools to reinforce my understanding of a concept in class.	Wright, 2017	Inspired by the items "I can select appropriate content from web sources and Web 2.0 applications allow me to be a content producer rather than a user (consumer)", we wrote the new item.
8	I can produce content related to Web 2.0 tools and technologies.	Wright, 2017	We wrote the item based on the following two points: 'I can select appropriate content from web sources' and 'Web 2.0 applications allow me to be a content producer rather than a user (consumer).'
9	When I think of technology in education, I think of Web 2.0 tools.	Hew & Cheung, 2013; Timur et al., 2020	What comes to mind when you think of technology? Please specify. We wrote the article in response to the question.
10	I attend training on Web 2.0 tools.	Hew & Brush, 2007	Would you like to attend training on Web 2.0 tools? Why? We wrote the item in response to the question.
11	My knowledge of Web 2.0 tools makes me feel professionally inadequate.	Wright, 2017	We wrote the item based on the question, 'I consider myself competent when using Web 2.0 applications in daily life'.
12	I think that Web 2.0 tools will contribute to students' future lives.	Arslan & Görgülü Arı, 2021	We wrote the item based on the question, 'Do you think Web 2.0 tools will contribute to students' future lives? Why?'
Affective Dimension			
13	I am aware that Web 2.0 tools will have a positive impact on my professional life.	Wright, 2017	We revised the item: "Using Web 2.0 applications enables me to develop the skills needed in today's modern and technological world."
14	I do not want to learn Web 2.0 tools.	Wright, 2017	We wrote the item based on the statement, 'Using Web 2.0 applications contributes to my motivation level in my lessons and studies.'
15	I have high expectations for the Ministry of	Tondeur et al., 2017	We wrote the item based on the question, 'What are the expectations of science teachers from the

	National Education to provide training on Web 2.0 tools.		Ministry of National Education regarding the creation and organization of the content of websites for their courses?'
16	I want to offer a course on Web 2.0 tools.	Ertmer et al., 2012	We wrote the item based on the question, 'Would you like to work in technology in the future? Why?'
17	The more I use Web 2.0 tools, the more I want to teach science.	Wright, 2017	We revised our item to the sentence 'Using Web 2.0 applications contributes to my motivation level in my lessons and studies.'
18	I do not have the desire to learn Web 2.0 tools.	Arslan & Görgülü Arı, 2021	We wrote the item based on the study's idea of the desire to learn Web 2.0 tools.
19	I am eager to learn more about Web 2.0 tools.	Teo, 2011	We wrote the item based on the study's idea of the desire to learn Web 2.0 tools.
20	I believe that students learn better with Web 2.0 tools.	Arslan & Görgülü Arı, 2021	We wrote the item based on the statement, 'I think that Web 2.0 tools increase academic success in courses.'
21	I believe that Web 2.0 tools distract students from the lesson's interest.	Ertmer et al., 2012; Hew & Cheung, 2013	We wrote the item based on 'STEM practices distract students' interest and attention towards the lesson'.
22	Web 2.0 tools encourage students to engage in learning.	Ertmer et al., 2012; Hew & Cheung, 2013	We transformed it from the statement 'STEM practices improve students' self-confidence'.
23	I believe that Web 2.0 tools place responsibility on teachers.	Redecker et al., 2009	We wrote the item based on the study's ideas about teachers and responsibility.
24	I am motivated by my colleagues' use of Web 2.0 tools.	Timur et al., 2020	We wrote the item based on the question, 'Would you recommend using Web 2.0 applications to other colleagues (what advice would you give)?'
25	I want to enrich my lessons with Web 2.0 tools.	Greenhow et al., 2009	We wrote this item based on the study's ideas on teaching materials.
Psychomotor dimension			
26	Using Web 2.0 tools in class can be time-consuming.	Ertmer et al., 2012; Hew & Cheung, 2013	We wrote this item based on the statement, 'Implementing STEM activities is a waste of time.'
27	Using Web 2.0 tools in class causes problems.	Hew & Brush, 2007	We wrote this item based on our observations of the technological issues encountered during the study.
28	Using Web 2.0 tools in distance learning situations facilitates learning.	Hrastinski, 2009	We wrote this item based on the study on distance education and learning.
29	It would be difficult for me to learn Web 2.0 tools.	Arslan & Görgülü Arı, 2021	We wrote this item based on the study's idea about learning.
30	I find it challenging to use Web 2.0 tools.	Arslan & Görgülü Arı, 2021	We wrote this item based on the study on distance education and learning.
31	I do not think my manual skills are sufficiently developed using Web 2.0 tools.	Science educator*	The expert recommended the item.
32	I can easily turn Web 2.0 tools on and off.	Science educator *	The expert recommended the item.
33	As I utilize Web 2.0 tools, I believe my ability to conduct lessons with them has improved.	Science educator *	The expert recommended the item.
34	Web 2.0 tools enhance my ability to utilize	Science educator *	The expert recommended the item.

	technology effectively.		
35	Web 2.0 tools contribute to my technology literacy.	Science educator *	The expert recommended the item.
36	Web 2.0 tools enhance my multitasking.	Science educator *	The expert recommended the item.
37	Web 2.0 tools help me provide more thoughtful feedback to students.	Science educator *	The expert recommended the item.

* These items are suggested by science education experts based on the definitions of the affective dimension and awareness.

Note: English versions of the items are presented in the table. Turkish versions were used during the implementation.

3.2. Exploratory Factor Analysis

To conduct EFA, Bartlett's test should be significant, and the Kaiser-Meyer-Olkin (KMO) value should be greater than .60. While Bartlett's test of sphericity provides a context for the data's normality, the KMO test indicates the adequacy of the sample (Pallant, 2016). Principal Component Analysis (PCA) was first conducted to determine the factor structure of the draft scale. PCA identifies the principal components that explain the variance in the data and is typically performed as the first step before factor analysis. The components obtained by PCA are used to determine the factor structure and to understand which components the items load on (Pallant, 2016).

The varimax rotation technique was used to clarify further the factor structure resulting from the PCA. Varimax is an orthogonal rotation method that ensures independence among factors. This approach rotates the factor loadings to maximize variance, making it easier to see which variables strongly associate with a single factor. Consequently, interpreting the factors and identifying which items belong to each one becomes simpler (Pallant, 2016). As a result of the PCA and Varimax rotation procedures, the KMO value was found to be .94, and Bartlett's Test of Sphericity was found to be significant (Table 3). The KMO value measures sample adequacy; if it is greater than .60, the sample is considered adequate. On the other hand, Bartlett's Test of Sphericity tests whether the data are suitable for factor analysis. If it is significant, the data are suitable for factor analysis.

Table 3. KMO and Bartlett's sphericity test results

KMO		.94
Bartlett's Test of Sphericity	X ²	5278.38
	df	666
	p	.00

In the six-factor structure, items 14, 15, 28, and 31 overlapped. Overlapping items load significantly on multiple factors, indicating they do not belong to any single factor. Therefore, these items were eliminated or restructured from the scale. Items 1, 2, 14, 18, and 31 overlapped when the analysis was redone with fewer parameters. According to the scree plot, the analysis was repeated with two components. Items 11, 2, 1, 15, and 31 had extraction values of .12, .16, .28, .26, and .25. Only item 11 was eliminated owing to a low extraction value. Other item factor loadings were checked. We found no factor for item 11. Items 1, 2, 14, 18, and 31 were deleted from the scale because they overlapped.

A scree plot is a graphical method used in factor analysis to determine the number of factors. It identifies this by observing drops in eigenvalues and flattening of the curve after a certain sequence (Ledesma et al., 2015). In this study, the Scree Plot shows no more than two factors (see Figure 1). We found that the two-factor model explains the scale's structure in our analyses. The sharp decline in the graph, followed by a slowdown, indicates two main variables; adding more factors does not improve the model. Therefore, the scale's two-factor structure is confirmed.

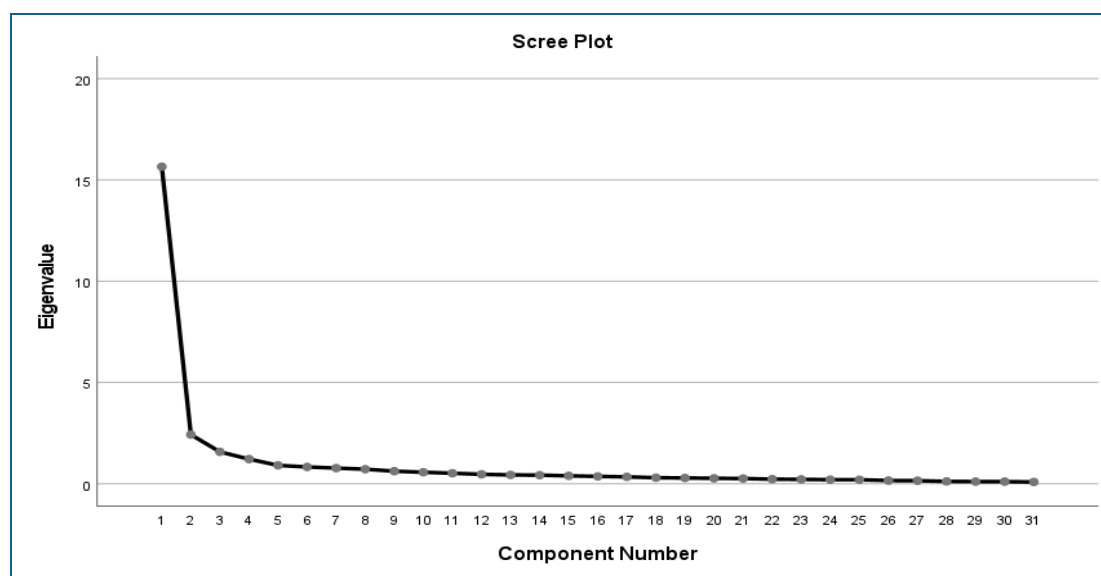


Figure 1. Number of significant factors according to the scree plot

Table 4. Factors and total variance explained.

Factor	Value			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	Variance percentage	Cumulative Percentage	Total	Variance percentage	Cumulative Percentage	Total
1	15.65	50.50	50.50	15.66	50.50	50.50	15.59
2	2.42	7.83	58.33	2.43	7.83	58.34	3.70
3	1.57	5.08	63.42				
4	1.22	3.93	67.36				
5	.91	2.93	70.30				
6	.83	2.68	72.98				
7	.77	2.50	75.48				
8	.72	2.32	77.81				
9	.62	2.01	79.82				
10	.57	1.82	81.67				
11	.52	1.68	83.35				
12	.46	1.51	84.86				
13	.44	1.41	86.28				
14	.42	1.37	87.66				
15	.39	1.27	88.93				
16	.36	1.18	90.11				
17	.34	1.10	91.22				
18	.30	.97	92.19				
19	.28	.92	93.12				
20	.27	.87	94.00				
21	.26	.84	94.84				
22	.23	.74	95.58				
23	.21	.70	96.29				
24	.20	.65	96.94				
25	.20	.65	97.59				
26	.16	.52	98.12				
27	.15	.49	98.61				
28	.12	.38	99.00				
29	.11	.35	99.35				
30	.10	.34	99.70				
31	.09	.29	100.00				

As shown in Table 4, a two-factor structure accounting for 58.34% of the total variance was identified.

Table 5. *Factor loadings of the items*

Item Number	Factors	
	1	2
M25	.86	
M24	.85	
M34	.84	
M20	.82	
M19	.80	
M12	.80	
M35	.80	
M6	.80	
M13	.79	
M37	.79	
M5	.79	
M9	.79	
M36	.78	
M16	.78	
M22	.78	
M7	.77	
M4	.77	
M3	.76	
M8	.73	
M17	.73	
M32	.69	
M23	.68	
M33	.68	
M10	.66	
M28	.63	
M15	.51	
M26		.74
M30		.73
M29		.72
M27		.70
M21		.61

As a result of repeated EFA, a two-factor structure comprising 31 items, explaining 58.34% of the variance, was obtained. As a result of the factor analysis, we observed that the scale has a two-factor structure. The first factor explains 50.50% of the total variance and has 26 items (M25, M24, M34, M20, M19, M12, M35, M6, M13, M37, M5, M9, M36, M16, M22, M7, M4, M3, M8, M17, M32, M23, M33, M10, M28, and M15). The items in this factor have high factor loadings, indicating strong interrelationships (Finch, 2020). The second factor accounts for 7.83% of the total variance and comprises five items (M26, M30, M29, M27, and M21). These items also form a consistent internal structure (Table 5)

3.3. Confirmatory Factor Analysis

The EFA-identified structure was tested using CFA. In this process, factor loadings, t-values, and goodness-of-fit indices were assessed. First, the chi-square statistic was divided by the degrees of freedom. None of the t-values were indicated with a red arrow (see Figure 2).

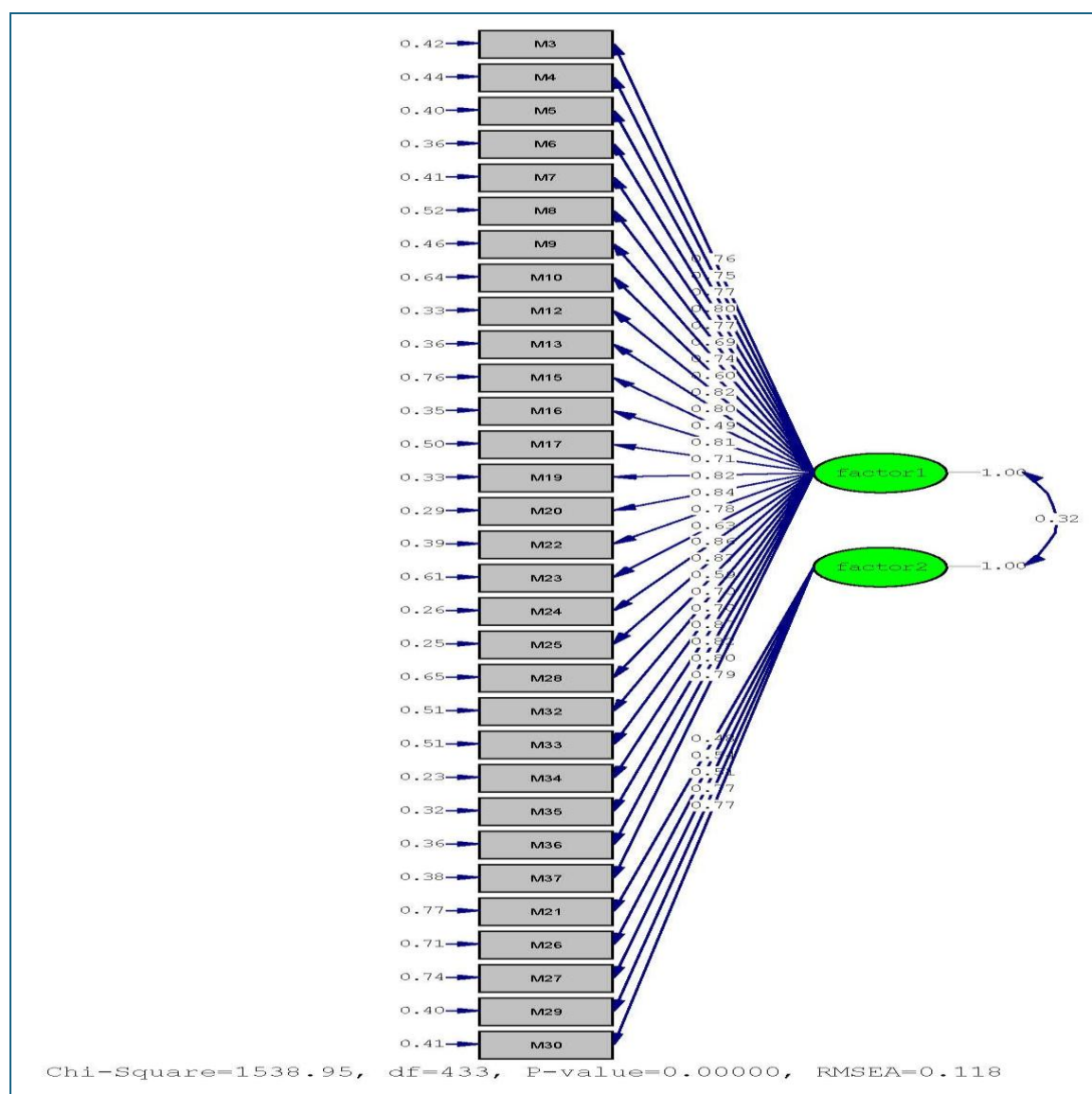


Figure 2. Factor numbers and loadings according to CFA results

Table 6. CFA goodness of fit indices

Fit Index	Acceptable Limit	Perfect Fit Limit	Value of the Scale	The scale's fit decision
NFI	=.90 and up	.95 and up	.94	Acceptable
NNFI	=.90 and up	.95 and up	.96	Excellent
CFI	=.95 and up	.97 and up	.96	Acceptable
IFI	=.90 and up	.95 and up	.96	Excellent
RFI	=.90 and up	.95 and up	.94	Acceptable
RMSEA	between .50 and =.80	=.000 and < .050	.12	Not acceptable
χ^2/df	$3 \leq \chi^2/df \leq 5$	$\chi^2/df < 3$	3.55	Acceptable

Source: (Schumacher & Lomax, 2004)

The CFA results demonstrate that the model fits well and the two-factor structure is valid (Table 6). The chi-squared /df ratio and other goodness-of-fit indices fall within acceptable limits, though the RMSEA does not. Aside from the RMSEA, other indices support the structure. Even if RMSEA is high in similar cases, additional fit indices confirm the model's validity (Brown, 2015). The goodness-of-fit index indicates that the model fits the data well, supporting scale construct validity.

3.4. Measurement Invariance

The two-factor structure obtained from EFA and confirmed by CFA was checked to determine whether it maintained the same gender structure. CFI and SRMR indices were compared (Table 7).

Table 7. *Measurement invariance results*

Type of Invariance	CFI	SRMR
Structural	.77	.08
Metric	.77	.09
Scaler	.77	.09
Strict	.75	.09

Table 7 shows CFI and SRMR values for various invariances. The invariance analysis examined structural, metric, scalar, and strict invariance. Structural invariance refers to the consistency of factor structure across groups. CFI and SRMR values were .77 and .08, respectively, demonstrating structural invariance. Structural invariance refers to the extent to which components of an assessment instrument represent the same psychological construct across groups. Metric invariance occurs when item factor loadings of a measurement instrument are consistent across groups. The metric invariance CFI is .77, and the SRMR is .09. These data indicate metric invariance, meaning that items perform similarly across groups. Scaler invariance means both groups have identical item values. CFI was .77 for scalar invariance, while SRMR was .09. These values prove scalar invariance. Scalar invariance ensures that different groups obtain comparable scores on the same scale, thereby ensuring comparable scale outcomes across groups. Strict invariance requires similar error terms across comparison groups. CFI for tight invariance is .75, while SRMR is .09. These values indicate strict invariance. Measurement error does not affect group comparisons because strict invariance ensures that terms are consistent.

In parallel with these observations, we noted that the differences between CFI and SRMR values were minor, less than .01. This indicates that the scale meets the assumptions of structural, metric, scalar, and strict invariance. These findings suggest that the scale can be used consistently and reliably across different groups and that the results are valid. These positive results of the invariance analysis suggest that the scale has strong psychometric properties and can measure the same construct across different demographic groups.

3.5. Reliability

The Cronbach's alpha reliability coefficient for the two-factor scale, obtained from the validity checks, was .96. A coefficient above .70 indicates that the scale is highly reliable (Brown, 2002). In this case, the internal consistency of the 31-item scale is relatively high. The high Cronbach's alpha indicates that the scale items are consistent with one another and have a homogeneous structure.

Table 8. *Web 2.0 awareness scale and factors' reliability coefficients*

Factor	Items	Cronbach Alpha	CR	AVE	Sample Item
F1	M25, M24, M34, M20, M19, M12, M35, M6, M13, M37, M5, M9, M36, M16, M22, M7, M4,	.97	.97	.50	I know what purpose I will use Web 2.0 tools for in the lesson (e.g.,

	M3, M8, M17, M32, M23, M33, M10, M28, M15				assessment, attention-grabbing).
F2	M26, M30, M29, M27, M21	.76	.84	.50	Web 2.0 tools contribute to my technology literacy.
Total	31	.97	.98	.57	I believe that students learn better with Web 2.0 tools.

As Cronbach's alpha reliability coefficient nears +1.00, the test's reliability is considered to improve (Brown, 2002). Table 8 reveals that the Cronbach's alpha reliability coefficient for the overall scale is .97, while it is .76 for both the first and second factors. The reliability of the scale items and each factor is deemed satisfactory (Pallant, 2016). The composite reliability for the overall scale and each factor was assessed (Table 8). The overall scale demonstrates a Cronbach's alpha reliability value of .97, with a composite reliability of .98. Table 6 indicates that Cronbach's alpha reliability and composite reliability for each sub-dimension exceed .70 (Pallant, 2016). An AVE value of approximately .50 indicates composite reliability (Hair et al., 2011).

4. Conclusion and Discussion

4.1. Content Validity

The content validity of the Web 2.0 Tools Awareness Scale, developed for this study, was assessed through expert opinion, in line with established literature on scale development. The results show that the scale covers key dimensions for measuring teachers' awareness of Web 2.0 tools and that the items are aligned with the theoretical framework. Content validity is a vital stage in scale development, involving both a systematic definition of the construct's conceptual domain and empirical validation of that domain via structured expert review (DeVellis & Thorpe, 2021). The methods used in this study follow established standards for scale development, emphasizing expert evaluation as an essential approach to ensure the scale items are theoretically representative and relevant (Haynes et al., 1995; Polit & Beck, 2006).

The scale items are structured to cover sub-areas such as recognition, functional use, pedagogical integration, and the influence of Web 2.0 tools on educational processes. This scope aligns with contemporary strategies for integrating technology, emphasizing the importance of teachers' technical competencies alongside their pedagogical knowledge, and the integration of technology into educational practices (Mishra & Koehler, 2006; Voogt & Roblin, 2012). The current scale's explicit incorporation of the pedagogical dimension represents a significant differentiation, as much of the literature addresses content validity through technical skill acquisition or attitude-based frameworks, rather than adopting a comprehensive pedagogical viewpoint (Davis, 1989; Ozcinar et al., 2020; Teo, 2011). The current scale explicitly incorporates pedagogical awareness as a fundamental element. This shift is based on modern models of technology integration, which emphasize that effective use of educational technology requires not only technical skills and positive attitudes but also an understanding of how digital tools align with instructional objectives, learning processes, and student engagement (Mishra & Koehler, 2006). The scale provides a comprehensive and conceptually sound framework for evaluating teachers' readiness for technology integration, effectively addressing a significant gap in the current literature.

The assertion "I can use Web 2.0 tools in lesson plans" assesses teachers' understanding of how to incorporate technology into their instructional design. This finding aligns with the technological pedagogical content knowledge (TPACK) theoretical framework, which emphasizes integrating technology into instructional design (Mishra & Koehler, 2006). Chen and Chen (2025) argue that integrating Web 2.0 tools into lesson planning enhances student engagement and learning outcomes. This study investigates skill not through performance or instructional outcomes, but through awareness. This approach distinguishes it from application-oriented research in the literature, which primarily assesses the effectiveness of Web 2.0 tools via classroom implementations, experimental

interventions, or learning outcomes (Hursen, 2021; Laurillard, 2013; Voogt et al., 2013). This situation signifies a unique contribution to the scale.

The assertion that "I can enhance collaboration and communication among students through Web 2.0 tools" assesses teachers' understanding of how to promote constructivist learning environments. Haydn and Barton (2007) and Voogt and Roblin (2012) emphasize the significance of Web 2.0 tools in fostering interactive and collaborative learning environments. This aspect of the current scale aligns closely with the student-centered learning approach emphasized in academic literature. This study redirects attention from earlier assessments of educational technologies, which primarily framed teachers' engagement in terms of attitudes toward technology or usage frequency, to the construct of awareness, thus providing a conceptually distinct and theoretically informed perspective (Inan & Lowther, 2010; Ozcinar et al., 2020). This scale offers a new perspective in the literature by clarifying teachers' levels of cognitive readiness for technology use.

The statement "I think Web 2.0 tools increase student motivation" assesses educators' perceptions and understanding of how digital tools influence learning outcomes. This finding is consistent with research indicating the beneficial impacts of Web 2.0 tools on motivation, interaction, and learning outcomes (Kiziltaş & Kultas, 2025; Laurillard, 2013; Selwyn, 2014). In Hursen's (2021) study on problem-based learning, the effects of Web 2.0 tools were primarily analyzed in relation to academic achievement and higher-order thinking skills. This study evaluated the effect at the level of teacher awareness, using a comprehensive, leading measurement approach.

The study by Ozcinar et al. (2020) examined the attitudes of pre-service teachers and students toward Web 2.0 tools and found that effective use of these tools increased motivation and engagement. The results support the content validity of the current study. Importantly, the scale's focus on awareness instead of attitude sets it apart from existing measurement tools in the literature. This situation underscores the potential role of the scale in evaluating teachers' readiness to adopt technology.

The two-dimensional structure of the scale, comprising "Awareness of Educational Use" and "Awareness of Impact on Educational Processes," is broadly consistent with the digital pedagogical competency frameworks identified in the literature (Ertmer & Ottenbreit-Leftwich, 2010; Tsai & Chai, 2012). Within this context, the identified dimensions underscore theoretical perspectives asserting that effective technology integration requires teachers to understand not only how digital tools are used, but also how such use shapes learning processes, instructional quality, and student outcomes (Kirkwood & Price, 2014; Koehler et al., 2013; Tondeur et al., 2017).

The study's reliance on expert opinions alone to establish content validity represents a notable limitation. The quantity of experts and the variety of their fields can directly influence the robustness of content validity (Haynes et al., 1995). Future research should report quantitative content validity indices (CVIs) using a diverse panel of experts from multiple disciplines to strengthen the evidential basis for the scale's content validity (Lynn, 1986; Polit & Beck, 2006). Furthermore, applying the scale across different cultural and educational contexts is essential for examining the universality, transferability, and contextual sensitivity of its content coverage (Hambleton et al., 2004; Van de Vijver & Leung, 2021).

The findings of this study support current views on integrating educational technology, emphasizing that effective use of technology in teaching requires not only technical skills but also pedagogical knowledge and an understanding of learning processes. The study organizes the scale around dimensions that include the educational use of Web 2.0 tools and their perceived impact on instructional processes, aligning with theoretical ideas that highlight the connection between pedagogical reasoning and the use of digital tools (Kirkwood & Price, 2014; Tondeur et al., 2017). The scale's focus on awareness offers a unique contribution, setting it apart from commonly used tools that mainly assess teachers' digital pedagogical skills through attitudes, self-efficacy, or demonstrated abilities. This method enables a more comprehensive and conceptually precise evaluation of teachers' readiness to integrate technology (Schmidt et al., 2009).

4.2. Construct Validity

Two factors were found. The first factor assessed instructors' awareness of the educational applications of Web 2.0 tools, while the second measured their understanding of how these tools affect educational processes. According to Başpınar and Özel (2023), teachers' technological attitudes are divided into cognitive and affective factors. This study explained 41.70% of the variance, whereas ours explained 58.34%, suggesting that instructors are more knowledgeable about Web 2.0 tools. This more extensive explanation raises teachers' awareness of lesson planning, student interaction, and the role of technology in pedagogy, thereby fostering more inventive and effective educational practices.

The EFA initially identified a three-dimensional structure, but the analysis ultimately revealed a two-dimensional structure. This can be clarified by examining the item factor loadings to confirm the construct validity of the scale. In the intra-item additions, items 14, 15, 28, and 31 showed overlap, indicating they did not load onto a clear factor and should therefore be removed from the scale. The two-factor structure was identified with greater clarity and consistency. This finding is important because it offers a more accurate and dependable tool for measuring teachers' awareness of Web 2.0 tools, which is essential for developing innovative and effective educational methods.

This two-factor structure was tested using CFA. The CFA results indicated that the model demonstrated an acceptable fit and supported the validity of the proposed two-factor structure. The goodness-of-fit indices suggested that the model fit the data well, thereby providing evidence for construct validity (Hu & Bentler, 1999; Kline, 2016). On the other hand, the RMSEA value exceeded .10. It should be noted that RMSEA tends to increase as the number of observed variables and model complexity increase, particularly in models with limited degrees of freedom; therefore, RMSEA may be less suitable for models with a relatively small number of variables (Kenny et al., 2015). Cabrera-Nguyen (2010) suggested using multiple fit indices in CFA studies. Hu and Bentler (1999) suggested using any of the following binary criteria according to the two-index strategy: NNFI (at least .96) and SRMR (at most .09), RMSEA (at most .06) and SRMR (at most .09), CFI (at least .96) and SRMR (at most .09). Crowley and Fan (1997) suggested reporting as many indices as possible since each fit index provides information about a different aspect of model fit. Considering at least two or more of the recommendations (Brown, 2015; Hu & Bentler, 1999; Kline, 2016) on which fit indices to use will be an effective method in evaluating the model fit accurately and soundly. In line with the relevant literature recommendations, although the RMSEA value was not within the desired range in the current scale development study, we reported six goodness-of-fit indices in addition to this value (Table 6).

Following the psychometric analyses, the two-factor structure of the scale was further examined by gender to test measurement invariance. The findings indicated that the underlying factor structure was preserved across both groups, providing empirical evidence for invariance. This result demonstrates that the scale operates similarly for male and female teachers and can therefore be used to make meaningful comparisons across genders. Although measurement invariance testing is not yet standard practice in the national-scale development literature, the inclusion of such analyses represents a methodological strength of the present study, supporting the robustness of the scale's psychometric properties (Rutkowski & Svetina, 2014). The preservation of the factor structure across gender groups suggests that the scale yields consistent and unbiased scores, thereby enhancing its reliability and validity for comparative research. This emphasis on invariance is also well established in the international literature; for instance, Meredith (1993) underscores that establishing measurement invariance is a prerequisite for valid group comparisons and for drawing substantive conclusions about differences or similarities across populations. Taken together, these findings contribute to the scale development literature by demonstrating the feasibility and value of incorporating measurement invariance testing into awareness-based educational technology scales, thereby strengthening their applicability for both national and cross-group comparative research.

In discussing construct validity, comparisons with Park and Son's (2022) work highlight differences in the scales used in educational technology and how cultural context can influence their structure. Along

this axis, the factor structures obtained in Park and Son's study vary with participants' technology use and the features of their educational systems. Similarly, Tsai and Chai's (2012) study explored how cultural and regional differences impact teachers' use of Web 2.0 tools in Asia. The similarities and differences in these studies align with our findings. Overall, these results support the construct validity of the current scale by demonstrating that its factor structure is both theoretically consistent and context-sensitive, thereby contributing to the educational technology literature with an awareness-based measurement model that captures cultural and educational differences while maintaining conceptual clarity.

4.3. Reliability

In terms of reliability, the Cronbach's alpha value (.97) indicates that the scale has high internal consistency and can be used reliably with science teachers. In the literature, other scales that assess teachers' awareness of technology use and Web 2.0 tools also provide acceptable reliability values. However, they do not reach the same high value as in our study. For example, the scale developed by Çelik (2021) measures teachers' awareness of Web 2.0 tools. It yields a reliability value of 0.86. In our study, we did not rely solely on Cronbach's alpha to assess the scale's reliability. In addition, we calculated the composite reliability coefficient of .98. Similarly, multiple reliability coefficients for the scale have been examined in the literature (Hair et al., 2019; Raykov & Marcoulides, 2011; Sijtsma, 2009).

4.4. Implications

This study developed a Web 2.0 Tools Awareness Scale, grounded in a constructivist framework, to enhance science teachers' awareness of digital technologies. The scale is designed to help teachers align Web 2.0 tools with pedagogical goals and learning processes, in accordance with constructivist learning theories that emphasize active knowledge construction, interaction, and the meaningful use of digital tools (Kirkwood & Price, 2014; Tondeur et al., 2017). The scale aims to enhance teachers' awareness, rather than solely measuring usage frequency or attitudes, thereby potentially contributing significantly to student learning through more intentional, pedagogically informed technology integration (Schindler et al., 2017). The scale facilitates comparative studies of teachers' awareness levels across various disciplines, addressing a significant gap in the literature due to the scarcity of discipline-sensitive measurement tools (Tondeur et al., 2018). The constructivist orientation and awareness-based structure of the scale significantly contribute to the literature on scale development in educational technology, providing a theoretically grounded and transferable instrument for evaluating teachers' digital pedagogical readiness in research contexts. This study conceptualizes teachers' engagement with Web 2.0 tools within an awareness-based, constructivist framework, offering a theoretically grounded, methodologically robust measurement instrument that addresses a significant gap in the educational technology literature. This instrument provides a foundational framework for subsequent research on digital pedagogical readiness across various disciplines and educational contexts.

By systematically identifying gaps in teachers' technology integration practices, the Web 2.0 Tools Awareness Scale enables a more precise diagnosis of challenges frequently reported in the educational technology literature, supporting the development of targeted, evidence-based professional development strategies (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017). In this regard, the scale serves as a practical tool to support teachers' digital transformation by promoting reflective, pedagogically grounded use of technology, which is closely associated with improvements in instructional quality and student learning outcomes (Kirkwood & Price, 2014; Schindler et al., 2017). Beyond classroom practices, enhancing teachers' digital competencies through awareness-based assessment has broader implications for educational stakeholders, as it contributes to more effective learning experiences for students and facilitates stronger collaboration and support from parents and school communities (OECD, 2020). Accordingly, the scale provides a practical, scalable mechanism to enhance educational quality and facilitate adaptation to the evolving demands of the digital age.

4.5. Suggestions

Despite providing evidence for the content validity of the Web 2.0 Tools Awareness Scale, this study has several limitations that should be addressed in future research. First, criterion validity could not be examined because no independent instrument grounded in a comparable conceptual framework was available. Future studies are therefore encouraged to test criterion validity by comparing them with theoretically aligned measures and to report quantitative content validity indices (CVIs) based on evaluations from a more diverse and interdisciplinary panel of experts. Second, the sample was limited to teachers from a single geographical region, which may constrain the generalizability of the findings. Replication studies involving larger, more heterogeneous samples across different regions, disciplines, and educational levels are needed to enhance the scale's contextual robustness. Furthermore, longitudinal research designs could be employed to examine the stability of teachers' awareness over time and its relationship with actual technology integration practices. Finally, future research may explore the applicability and adaptability of the scale in emerging digital learning contexts, such as AI-supported educational environments, to further assess its relevance and flexibility in evolving educational systems.

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