

# A Scale Development for Visual Literacy on Health Students and Professionals

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**Objective:** Viewing that there is a lack of valid and reliable measures to assess visual literacy in clinical and healthcare settings, this study aimed to develop a visual literacy scale to assess health students' and professionals' visual literacy, by which teachers can further help them sharpen their visual literacy skills and sensitivity to let them reach effective communication in clinical and healthcare settings.

**Methods:** The scale was constructed according to Slavec and Drnovšek's three-phase scale development process: theoretical significance and existence of the scale construct, representative data collection and appropriate data collection methods, and statistical analysis of data collection and statistical evidence of the scale construct. To investigate the psychometrical properties, the researchers first performed a pilot study on randomly selected 464 health students and professionals, using exploratory factor analysis (EFA) with SPSS to derive the hidden factor structure, and then on randomly selected 303 participants, using confirmatory factor analysis (CFA) with AMOS to validate the derived factor structure. Internal consistency, convergent validities, discriminant validities, and goodness-of-fit indices were also examined in the study.

**Results:** After going through the EFA, 30 items in three factors were identified: "allegorical meaning" (12 items), "explicit meaning" (10 items), and "symbolic meaning" (8 items). The three factors explained 73.191 of the total variance. The CFA generated the same three factors and 22 items: "allegorical meaning" (12 items), "explicit meaning" (4 items), and "symbolic meaning" (6 items). The three factors accounted for 75.022% of variance. Both the EFA and CFA models demonstrated satisfactory goodness-of-fit and good convergent and discriminant validities. Regarding the reliabilities, the Cronbach's alpha values in the EFA and CFA models were all above 0.90.

**Conclusion:** The findings have demonstrated that the VLS-HSP can be a formal instrument to measure visual literacy on health students and professionals.

**Keywords:** humanistic professional awareness, healthcare students and providers, scale development, psychometric properties

## Introduction

Effective communication between patients and health professionals involves using all the senses, as well as written texts, to see beyond the disease and to interpret from patients' facial expression or body languages to realize their suffering. In other words, health professionals should respect the patient as a whole person with humanness, not as the symptoms of sickness.<sup>1</sup> Therefore, in order to have effective communication with patients and their families, health professionals should equip themselves with observation ability and visual literacy to read the interactive meanings of images. However, it is not an easy way to read images.

With the rapid advancement of the Internet and audiovisual media, visual images have become an indispensable tool of communication today. However, some visual images conceal many ideologies and messages hidden in the images, which may not be perceived by students. Debes<sup>2</sup> first introduced the term "visual literacy" in 1968 as a set of visual abilities to observe and integrate other sensory experiences to develop visual abilities. Visually literate people are able to identify and understand not only visible actions and objects, but also symbols encountered. Moreover, they are able to understand, appreciate, and communicate with others through visual images. The International Visual Literacy Association (IVLA)<sup>3</sup> gave a brief definition to visual

literacy, saying that visual literacy is the ability to realize and generate visual information. The process of understanding and generating visual images actually includes two parts: decoding and encoding. One is the ability to capture or read (decode) meaningful verbal messages from images, and the other is the ability to use design elements (lines, shapes, colors, and proportions) to generate visual communication, in order to convey (encode) messages through external forms and symbols.<sup>4</sup>

Because visual literacy involves the ability to generate meaning from visual images (ie decode) and to synthesize meaningful visual images (ie encode),<sup>5</sup> it demands a series of competencies to let people discover, interpret, assess, use, and create images and visual aids efficiently. In health and medical care, with visual literacy, health and medical care students and professionals may use the decoding and encoding techniques to figure out the messages patients intend to express. If patients are embarrassed, fearful, or reluctant to consult doctors or other health professionals, such patients may withhold providing information to professionals.<sup>6</sup> However, with the presence of facial expressions, body language, and emotional features, such as visual cues, health professionals can take these nonverbal cues as visual images to figure out the intended meaning, which thus helps them decide what they can do to care for their patients.<sup>7</sup> Moreover, when patients are in a coma or in a state of intoxication, they may fail to express their ill symptoms to health professionals. However, with visual literacy, professionals can observe patients' emotion, body languages, or facial expressions, such as pallor, perspiration, erythema, as nonverbal cues to provide patients in-time healthcare.<sup>8</sup> As Katz and Khoshbin<sup>9</sup> indicated, visual literacy can improve health professionals' diagnostic skills and empathy with patients, along with their intellectual inquisitiveness and critical thinking.

In other words, in medical and health care, visual literacy skills, along with observation skills, can be particularly useful for visual-oriented professionals, such as dermatologists and radiologists, who use pattern recognition and visual literacy skills to identify and read visual images in physical examination results and associate them with a given diagnosis. With visual literacy, dermatologists can be skilled in pattern recognition to diagnose dermatologic conditions and identify subtle differences in test results. Likewise, radiologists need visual literacy skills when examining various imaging modes.<sup>10</sup> With no acquisition of visual literacy, it would be difficult to read the visual information derived from visual images or a sequence of visual images. On the surface, it would seem that visual images, in a sequence of panels, are easy to understand. Readers/spectators may think that these sequential images are only but a presentation (narrative) of certain events (meaning), ignoring the potential complexity of narrative storytelling functions of visual images.<sup>11</sup> From the perspective of linguistic and cognitive sciences, visual narratives involve more than the sequences of images and have greater complexity in encoding/decoding than widely assumed.<sup>12,13</sup> However, not much research has addressed how to comprehend the structure of the visual images.

Given that the training and acquisition of visual literacy skills for health students and professionals can help them improve visual diagnostic skills, clinical observation skills, and interprofessional communication,<sup>14,15</sup> there is a need to teach visual literacy in medical and healthcare education and design instruments to measure visual literacy in the clinical and healthcare settings. However, there is a lack of valid and reliable measures to assess visual literacy in Taiwanese clinical and healthcare settings. Therefore, it is necessary to develop a visual literacy scale to assess the level of visual literacy on health students and professionals; then, teachers can realize their visual literacy and hence design appropriate teaching strategies to help them increase their visual literacy. The objective of the research was to construct a visual literacy scale for health students and professionals in Taiwanese cultural backgrounds, by which teachers can further help them sharpen their visual literacy skills and sensitivity to let them reach effective communication in clinical and healthcare settings.

## Methodology

### Procedure and Participants

The study was proved by the Institutional Review Board of Chung Shan Medical University Hospital (CSMUH No:CS2-20198, dated March 30, 2021). The time frame was from August 1, 2021 to July 31, 2022. The participants were recruited on site in medical universities and hospitals. Informed consent from the study participants was obtained before the start of the study. The scale was constructed according to Slavec and Drnovšek's<sup>16</sup> three-phase and 10-step scale development process: theoretical significance and existence of the scale construct (Phase 1), representative data collection and appropriate data collection methods (Phase 2), and statistical analysis of data collection and statistical evidence of the scale construct (Phase 3). Phase 1 involved literature review and interviews (Step 1), scale items generation (Step 2), and evaluation of content validity (Step 3). Phase 2 involved scale development and evaluation (Step 4), scale

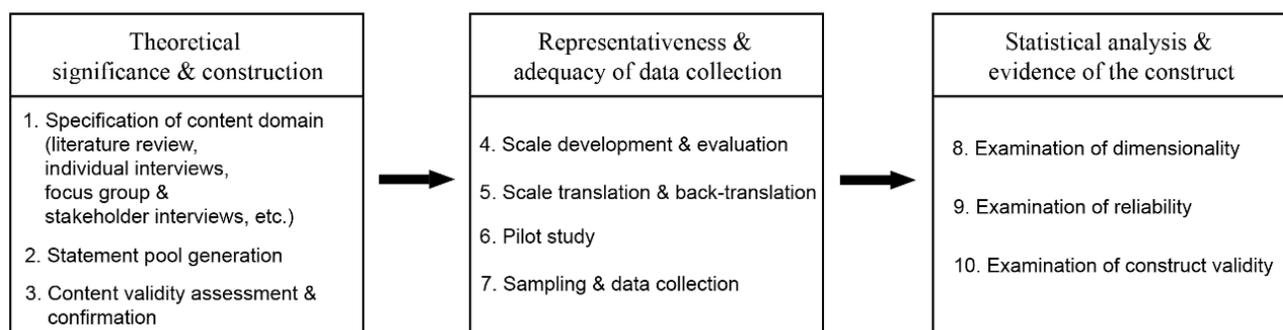
translation and back-translation (Step 5), a pilot study (Step 6), and sampling and data collection (Step 7). Phase 3 involved examinations of dimensionality (Step 8), reliability (Step 9), and construct validity (Step 10). The more detailed description of Slavec and Drnovšek' scale development process is shown in Figure 1.

Following a thorough review of literature, primarily in the following databases: ScienceDirect, PubMed, EBSCO, and ProQuest, with the search terms of visual literacy, visual images, visual literacy skills, observation skills, visual viewing skills, critical viewing skills, visual arts, etc., the researchers collected 76 items related to visual literacy. The researchers then held a panel discussion to examine whether these items addressed the theoretical concept.<sup>17</sup> The expert panel included three professors with more than fifteen years of expertise in medical humanities, social sciences, health education, and psychometrics. They reviewed and rated 76 items on a 6-point scale (0–5) for their relevance to the constructs (0 = extremely irrelevant; 5 = extremely relevant). Items rated below 4 were removed, and items on which the experts failed to reach consensus were discarded. Thus, after the panel discussed the items on the visual literacy scale, the 76 items on the 9-point Likert scale were reduced to 45 items (9: always; 1: never). The higher the score, the higher the visual literacy of the participants.

Moreover, as a priori hypothetical model, the 45 items were initially divided into three categories: “explicit meaning”, “symbolic meaning”, and “allegorical meaning”. The term “explicit meaning” referred to the literal or denotative meaning of a text or a discourse. The term “symbolic meaning” referred to an object, a person, or a place that represents an abstract idea that goes beyond its literal meaning. The term “allegorical meaning” referred to a story, fable, drama, or picture in which the characters and events represented moral, religious, historical, or political implications. Afterwards, the researchers translated the 45 scale items into Chinese, and back translated them into English, with two bilingual English instructors checking the semantic equivalence of the scale items to verify content and face validities.<sup>18</sup> Following panel discussions, the researchers first performed a pilot study on randomly selected 464 health students and professionals, using exploratory factor analysis (EFA) to derive the hidden factor structure, and then on randomly selected 303 participants, using confirmatory factor analysis (CFA) to validate the derived factor structure. The selection criteria for participants were those health professionals or students studying at medical universities or colleges. However, for those who studied in medical universities or colleges but whose specialization was not related to health or medical disciplines, they were excluded.

## Data Analysis

The researchers first conducted an exploratory factor analysis (EFA), using SPSS (version 14.0),<sup>19</sup> on 464 participants and later a confirmatory factor analysis (CFA), using AMOS (version 24.00),<sup>20</sup> on 303 participants to derive a potential factor structure and validate the factor structure. Also, eigenvalues, principal component analysis (PCA), promax rotation were taken to elicit the factor structure. The researchers also used the Kaiser–Meyer–Olkin test (KMO)<sup>21,22</sup> and Bartlett's sphericity test<sup>23,24</sup> to check whether the sample size was big enough for factor analysis.<sup>25</sup> Besides, the researchers used various model fit indices to check the goodness-of-fit of the EFA model (30-item scale) and that of CFA model (22-item model), in terms of  $\chi^2/df$  ratio,<sup>26</sup> Tucker Lewis Index (TLI),<sup>27</sup> comparative fit index (CFI),<sup>27</sup> and root mean square error



**Figure 1** Slavec and Drnovšek' scale development process.

of approximation (RMSEA).<sup>26</sup> Further, the convergent and discriminant validities of the scale and Cronbach's alphas and composite alphas were also tested.<sup>28,29</sup>

## Results

### EFA for the VLS-HSP Scale

To check psychometrical properties of the VLS-HSP scale, the researchers first adopted EFA on 464 participants to derive the potential factor structure of the VLS-HSP scale. Among the 464 valid participants, 298 participants (64.22%) were female, and 166 participants (35.78%) were male. A total of 305 participants (65.73%) were aged between 19 and 25, 32 participants (6.90%) aged between 26 and 32, 72 participants (15.52%) aged between 33 and 39, 46 participants (9.91%) aged between 40 and 46, and 9 participants (1.94%) aged 47 or above. Among these participants, 130 participants (28.02%) were health professionals, and 334 participants (71.98%) were health students. The participants' demographic characteristics are displayed [Table 1](#).

### KMO Test and Bartlett's Test of Sphericity

While using the KMO test<sup>21,22</sup> and Bartlett's test of sphericity<sup>23,24</sup> to check whether the sample size was big enough for factor analysis,<sup>25</sup> the researcher found that the KMO test and Bartlett's test of sphericity proved the appropriateness of the sample size for factor analysis,<sup>25</sup> with the KMO value (0.976) superior to the critical value 0.6<sup>30,31</sup> and Bartlett's test of sphericity being significant ( $p = 0.000 < 0.05$ ; approx. chi-square = 14,511.104; degree of freedom = 435). The scree-plot graphic (see [Figure 2](#)) suggested that there was an optimal three-factor solution for the VLS-HSP scale factors.

### 30-Items EFA Model

As mentioned, the researchers adopted EFA, to derive and validate the consistency of the scale factors. Also, eigenvalues (with values >1.0) and PCA were used to confirm the internal consistency and construct validity of the VLS-HSP scale.<sup>32</sup> In addition, to maximize high item loading values and minimize low item loading values, promax rotation (an oblique rotation method) was applied to produce more correlated construct structures.<sup>33</sup>

Moreover, in accordance with Hair et al's<sup>28</sup> factor structure criteria, an acceptable factor loading value should be higher than 0.5; a value equal to or higher than 0.70 is regarded as good to explain variables. Thus, in the study, if the factor loadings were bigger than 0.50 for the relevant factors, and less than 0.50 for the non-relevant factors, then the items were kept. After going through the EFA and PCA, three factors with 30 items were identified: "allegorical meaning" (12 items), "explicit meaning" (10 items), and "symbolic meaning" (8 items). The three factors remained in the VLS-HSP accounted for 73.191% of variance, with the eigenvalues all larger than one: 18.248, 2.645, and 1.064 (as shown in [Table 2](#)).

### Validity and Reliability Examination of the 30-Item EFA Model

As mentioned, the researchers translated the initial 45 scale items into Chinese version and back translated into English, with two bilingual English instructors checking the semantic equivalence of the scale items to verify content and face validities.<sup>18</sup> Afterwards, the researchers had three college students read and answered the scale item to ensure clarity.

**Table 1** Participants' Demographic Characteristics- EFA

Characteristics	Categories	Number	Percentage
Gender	Male	166	35.78%
	Female	298	64.22%
Age	19+ to 25 years old	305	65.73%
	26+ to 32 years old	32	6.90%
	33+ to 39 years old	72	15.52%
	40+ to 46 years old	46	9.91%
	47+ years old	9	1.94%
Source	Health professionals	130	28.02%
	Health students	334	71.98%

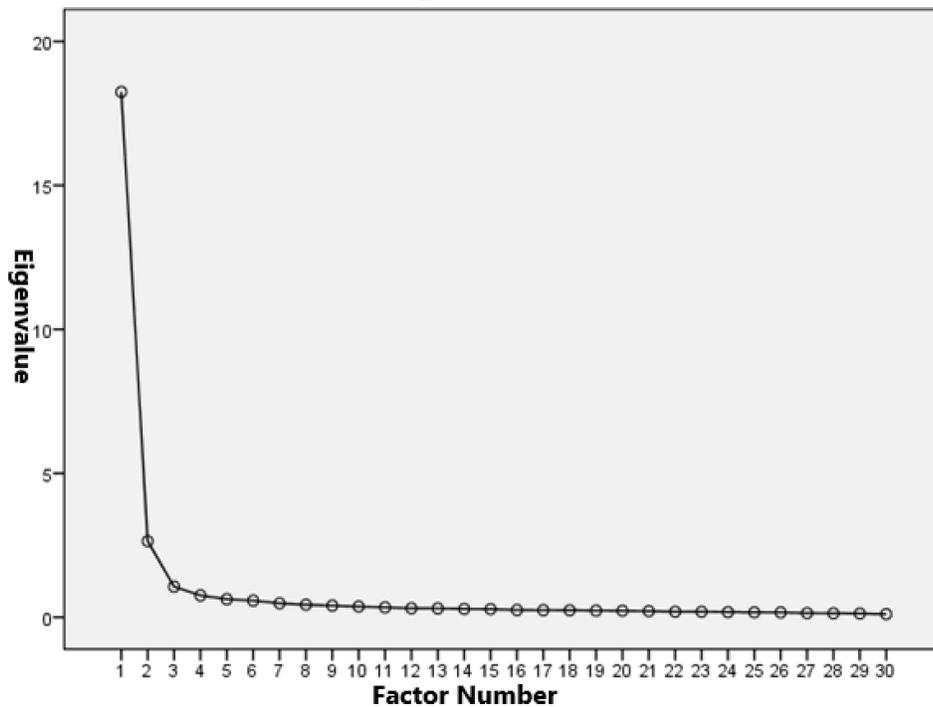


Figure 2 Scree plot for factor analysis of the VLS-HSP.

To check the internal consistency of responses in the multi-item VLS-HSP scale, the researchers calculated the Cronbach’s alpha<sup>26,27</sup> to check the coherence of the constructs, with Cronbach’s alpha 0.70 as acceptable and 0.8 or greater as preferable.<sup>34</sup> After the Cronbach’s alpha examination, the statistic results showed that the Cronbach’s alpha for the VLS-HSP scale was 0.978, with the Cronbach’s alphas 0.969, 0.948, and 0.953 for the subscales “allegorical meaning”, “explicit meaning”, and “symbolic meaning”, respectively (see Table 2).

Table 2 Factor Loadings, Cronbach’s  $\alpha$ , and Eigenvalues of the 30-Items EFA Model

Item	Factor 1: Allegorical Meaning	Factor 2: Explicit Meaning	Factor 3: Symbolic Meaning
Factor 1: $\alpha = 0.969$			
42	<b>0.983</b>	-0.056	-0.073
41	<b>0.929</b>	-0.021	-0.029
43	<b>0.906</b>	0.000	-0.022
38	<b>0.897</b>	0.081	-0.084
37	<b>0.841</b>	-0.051	0.060
44	<b>0.815</b>	0.090	-0.013
40	<b>0.809</b>	-0.009	0.099
34	<b>0.785</b>	-0.033	0.125
33	<b>0.728</b>	0.033	0.107
35	<b>0.706</b>	0.076	0.120
32	<b>0.675</b>	0.044	0.178
30	<b>0.674</b>	-0.039	0.200

(Continued)

**Table 2** (Continued).

Item	Factor 1: Allegorical Meaning	Factor 2: Explicit Meaning	Factor 3: Symbolic Meaning
Factor 2: $\alpha = 0.948$			
7	0.135	<b>0.873</b>	-0.165
4	-0.145	<b>0.867</b>	0.155
3	-0.024	<b>0.864</b>	0.021
5	-0.010	<b>0.850</b>	0.006
6	0.131	<b>0.816</b>	-0.132
2	-0.186	<b>0.793</b>	0.248
8	0.232	<b>0.779</b>	-0.134
11	0.145	<b>0.762</b>	-0.115
1	-0.298	<b>0.733</b>	0.324
10	0.178	<b>0.715</b>	-0.072
Factor 3: $\alpha = 0.953$			
18	0.036	-0.153	<b>0.945</b>
19	0.088	-0.010	<b>0.799</b>
23	0.150	0.082	<b>0.707</b>
20	0.231	0.088	<b>0.631</b>
24	0.175	0.174	<b>0.587</b>
22	0.298	0.089	<b>0.575</b>
25	0.290	0.073	<b>0.572</b>
26	0.288	0.125	<b>0.510</b>
Eigen value	18.248	2.645	1.064
% of variance	60.825	8.818	3.548

**Notes:** Overall  $\alpha = 0.978$ ; total variance explained of the scale=73.191%. The bold font refers to the factor loadings bigger than 0.50 for the relevant factors, and less than 0.50 for the none-relevant factors.

### Descriptive Statistics of the 30-Items EFA Model

The item descriptions, means, and standard deviations of the 30-items EFA model are shown as [Table 3](#).

### CFA for the VLS-HSP Scale

After the application of EFA, to determine the structure of potential factors of the VLS-HSP scale, the initial 45 items were reduced to 30 items in consideration of three factors. To further examine the derived factor structure, the researchers adopted the CFA to evaluate the structure of potential factors of the VLS-HSP scale from the 303 participants.

Of the 303 valid participants, 197 participants (65.02%) were female and 106 participants (34.98%) were male. A total of 183 participants (60.40%) aged between 19 and 25; 29 participants (9.57%) aged between 26 and 32; 52 participants (17.16%) aged between 33 and 39; 33 participants (10.89%) aged between 40 and 46, and 6 participants (1.98%) aged 47 or above. Among these participants, 64 participants (21.12%) were health professionals, 239 participants (78.88%) were health students. The participants' demographic characteristics are displayed [Table 4](#).

Using the AMOS,<sup>20</sup> the CFA obtained the same three factors and 22 items, without removing any items in factor 1 (allegorical meaning), but removing 6 items in factor 2 (explicit meaning), and removing 2 items in factor 3 (symbolic meaning). Thus, the shorter CFA model included only 22 items: "allegorical meaning" (12 items; factor loadings: 0.827–0.923), "explicit meaning" (4 items; factor loadings: 0.836–0.885), and "symbolic meaning" (6 items; factor loadings: 0.823–0.911). The three factors accounted for 75.022% of variance. The 22-item CFA model for the VLS-HSP scale is shown in [Figure 3](#) and in [Appendix](#).

**Table 3** Item Descriptions, Means, and Standard Deviations of the 30-Items EFA Model

Factor and Item	Mean	S.D.
I. Allegorical Meaning	70.266	15.465
42. I can understand the social, cultural, and political implications in an image.	5.81	1.552
41. I can place images in their cultural, social, and historical context and interpret them in depth.	5.70	1.513
43. I can infer the deep meaning implied by the image creator from the details of the image.	5.80	1.548
38. I can recognize the discourse position, creative techniques, and characteristics of image creators.	5.84	1.481
37. Through the images as historical texts, I can understand the multiple political, social, and cultural implications behind them.	5.82	1.525
44. I can gain insight into the intention of the image creator from the details of the image.	5.85	1.580
40. I can identify the deep cultural meaning laid out by the image creator.	5.80	1.501
34. I can make a systematic interpretation of the cultural or historical representations of pictorial works, and summarize the humanistic ideas or epochal meanings they want to express.	5.90	1.484
33. I am able to recognize the significance of images in their historical context. For example: the historical background and importance of the crusades.	5.89	1.494
35. I can recognize the constructed meaning of the image and the ideological content behind it.	5.91	1.464
32. I can examine contextual context within or between images and draw appropriate inferences from their clues.	5.97	1.395
30. I can identify the moral, legal, or ethical issues that the image creator intends to imply through the image.	5.98	1.372
II. Explicit Meaning	62.351	11.471
7. I know that images are composed of colors, shapes (such as points, lines, and planes), textures, spaces, etc. to represent the things they represent.	6.18	1.443
4. I can describe the expressions, postures, dresses, etc. of the characters in the image.	6.35	1.409
3. I can describe the basic design elements to be presented in the image (eg composition, contrast, repetition, style, etc.).	6.20	1.383
5. I can describe the subject, title, data, etc. to be presented in the image.	6.21	1.396
6. I know that an image should also contain some meaning that goes beyond its superficial form, although I do not know what it implies.	6.14	1.444
2. I can describe the basic visual elements of an image (eg color, typography, lines, shapes, etc.).	6.41	1.339
8. I can describe the concept that an image intends to express.	6.10	1.417
11. I can describe the emotion that an image intends to express.	6.16	1.338
1. I can describe the colors that images (eg, still drawings, photographs, cartoons, maps, etc.) want to present.	6.49	1.331
10. I have the ability to perceive the visual symbols of an image.	6.12	1.394
III. Symbolic Meaning	49.453	9.729
18. I can recognize the cultural and customary meaning of images. For example, in Western culture, taking off a hat and lifting it is not just a simple hat lifting action but like a handshake, it is a salute gesture.	6.48	1.431
19. I can recognize the cultural customs implied by the image in its external forms such as colors, typography, lines, and shapes. For example, in the Tang Dynasty, purple was regarded as an elegant color and a favorite color of the royal family.	6.13	1.449
23. I can infer the information implied in the story through my own knowledge or experience, such as the possible traits, psychology, emotion and state of the characters, or the tone or atmosphere in the story.	6.34	1.383
20. I can use the context shown in the image to interpret the visual message it wants to express.	6.06	1.360
24. I can summarize the message or theme that the image is trying to convey.	6.17	1.407
22. When I see an image, I can understand the meaning of the symbols or graphics used as visual effects.	6.15	1.356
25. I can interpret and analyze the meaning of charts or graphs.	6.10	1.402
26. I can find the purpose and meaning of an image in the context of a pattern or a set of patterns.	6.03	1.420

Abbreviation: S.D., standard deviation.

### Goodness-of-Fit Examination

To further look into the goodness-of-fit of the 30-item EFA model and 22-item CFA model, the researchers used various fit indices to crosscheck the goodness-of-fit. For an acceptable  $\chi^2/df$  ratio, no agreement has been reached, some suggested an acceptable  $\chi^2/df$  ratio in the range from 5.0 to 2.0,<sup>35,36</sup> others suggested a  $\chi^2/df$  ratio below 2.0 to be considered as acceptable.<sup>37,38</sup> As for TLI, a larger TLI value indicates a better model fit, with a minimum value of 0.90

**Table 4** Participants' Demographic Characteristics- CFA

Characteristics	Categories	Number	Percentage
Gender	Male	106	34.98%
	Female	197	65.02%
Age	19+ to 25 years old	183	60.40%
	26+ to 32 years old	29	9.57%
	33+ to 39 years old	52	17.16%
	40+ to 46 years old	33	10.89%
	47+ years old	6	1.98%
Source	Health professionals	64	21.12%
	Health students	239	78.88%

being acceptable, and a value of 0.95 being excellent.<sup>39,40</sup> As for CFI, a CFI value bigger than 0.90 is considered acceptable, and a value of 0.95 or above is regarded as excellent for a model fit.<sup>41</sup> As for the RMSEA index which assesses the difference between a hypothesized model and an observed model.<sup>42</sup> For MacCallum et al,<sup>43</sup> an RMSEA index ranged between 0.08 and 0.10 is regarded only a moderate goodness-of-fit, with an index smaller than 0.02 showing a good model fit. In accordance with Hu and Bentler,<sup>41</sup> an RMSEA index below 0.08 is considered as an acceptable goodness-of-fit, while an index less than 0.05 is considered excellent goodness-of-fit.<sup>41</sup> Table 5 shows the goodness-of-fit index results of the 30-item EFA model and 22-item CFA model.

### Reliability

The researchers further checked the stability and internal consistency of the 22-item CFA model, with the Cronbach's alpha and composite reliability values above 0.70 being acceptable.<sup>28,34</sup> After calculation (as in Table 6), it was found that the 22-item CFA model has excellent reliabilities in both the Cronbach's alphas (0.972, 0.913, 0.950, and 0.977, respectively) and composite reliability (0.973, 0.917, 0.947, and 0.984, respectively) examinations in "allegorical meaning", "explicit meaning", and "symbolic meaning" subscales and entire VLS-HSP scale.

### Convergent Validity

To examine whether the scale items in the VLS-HSP scale can converge to represent the underlying construct, the researchers used AVE values and composite reliabilities<sup>28,29</sup> to look into the convergent validity of the scale. The convergent validity can be established on condition that the AVE values are bigger than 0.50, but smaller than the composite reliabilities, which should be bigger than 0.6.<sup>28,29</sup> After calculation (as shown in Table 6 and Table 7), it was proven that the VLS-HSP scale met the criteria of convergent validity in that the AVE values for "allegorical meaning" (0.753), "explicit meaning" (0.735), and "symbolic meaning" (0.747) were all bigger than 0.50<sup>28,30</sup> and also smaller than the corresponding composite reliability values (0.973, 0.917, and 0.947, respectively; >0.6).

### Discriminant Validity

The discriminant validity can be demonstrated on condition that the  $\sqrt{AVE}$  of a factor is higher than its correlation coefficient ( $r$ ) with other factors.<sup>44</sup> After calculation (as in Table 7), it is shown that the criterion is satisfied in terms of the discrimination between "allegorical meaning" and "explicit meaning" ( $\sqrt{AVE}=0.868$  and  $0.857$ ;  $r=0.668$ ), between "explicit meaning" and "symbolic meaning" ( $\sqrt{AVE}=0.857$  and  $0.864$ ;  $r=0.786$ ), and between "symbolic meaning" and "allegorical meaning" ( $\sqrt{AVE}=0.868$  and  $0.864$ ;  $r=0.834$ ).

After going through a series of examinations, including sample size test, model fit tests, validity tests, reliability tests, etc., it has been proven that the 30-item EFA model and 22-item CFA model can be taken as an instrument in assessing participants' visual literacy.

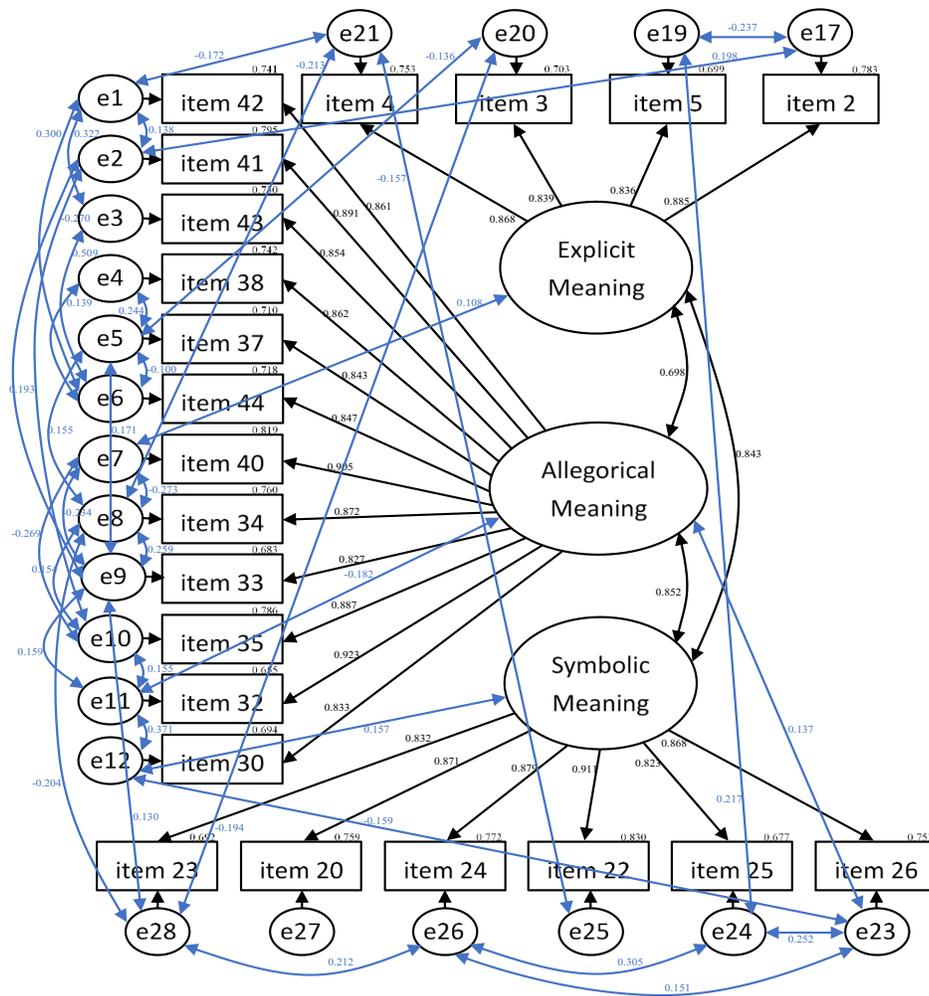


Figure 3 The 22-item CFA model for the VLS-HSP.

## Discussion

This study was to build a comprehensive and psychometric scale applicable to the assessment of visual literacy for health students and professionals. In verifying the psychometrical properties of the VLS-HSP scale, the researchers first used the EFA to check the structure of potential factors in the dataset, followed by CFA to verify the fit of the dataset to the model.<sup>44,45</sup> The researchers first applied the EFA to create a preliminary 30-item EFA model, with three factors, for the

Table 5 Goodness-of-Fit Index Results of the 30-Item EFA Model and 22-Item CFA Model

	$\chi^2$	df	$\chi^2/df$	p	TLI	CFI	RMSEA
30-item EFA model	1264.285	402	3.145	0.000	0.907	0.914	0.084
22-item CFA model	205.306	168	1.222	0.026	0.993	0.995	0.027

Abbreviations: df, degree of freedom; TLI, Tucker Lewis index; CFI, comparative fit index; RMSEA, root mean square error of approximation.

**Table 6** Cronbach's Alpha and Composite Reliability Values of the 30 Item EFA Model and the 22-Item CFA Model

Reliability Factor	Cronbach's Alpha: 30-Item EFA Model	Cronbach's Alpha: 22-Item CFA Model	Composite Reliability: 22-Item CFA Model
Allegorical meaning	0.969	0.972	0.973
Explicit meaning	0.948	0.913	0.917
Symbolic meaning	0.953	0.950	0.947
Overall	0.978	0.977	0.984

**Table 7** AVE,  $\sqrt{AVE}$ , and Correlation Coefficients (*r*) with Other Factors

Factor	AVE	1	2	3
1. Allegorical meaning	0.753	<b>0.868</b>		
2. Explicit meaning	0.735	0.668***	<b>0.857</b>	
3. Symbolic meaning	0.747	0.834***	0.786***	<b>0.864</b>

Notes: The values shown in bold are the  $\sqrt{AVE}$ ; the other values are *r*; \*\*\**p*<0.0001.

VLS-HSP scale. The three factors were “allegorical meaning” (12 items), “explicit meaning” (10 items), and “symbolic meaning” (8 items). Further, the researchers employed the promax rotation to achieve the maximum possible variance, always falling at the first factor,<sup>26</sup> here “allegorical meaning” (60.825% of variance explained). Moreover, these three factors accounted for 73.191% of the variances.

The researchers further investigated the mean scores of the three subscales, it was found that the participants scored highest on the “explicit meaning” subscale (Mean=6.235 per item: 62.351÷10=6.235), followed by the “symbolic meaning” (Mean=6.182) and “allegorical meaning” (Mean=5.856). These mean scores indicate that the participants think that it was easier to understand the messages which were directly and explicitly expressed in the visual images, rather than the implicit meaning, the message not expressed in the visual images (eg, metaphorical language, symbolic meaning, or allegorical meaning). Additionally, they felt that compared to the allegorical meaning, a hidden meaning, typically a moral or political one, is easier to catch the symbolic meaning of a visual image, which uses a singular symbol or various symbols to represent a concept or ideas. Relatively, it would be difficult to understand the allegorical meaning, which is expressed through abstract ideas and political or historical situations via characters, events, or settings to reveal an underlying message which is not literally represented, with no customary or expected meaning.<sup>46</sup>

After creating the EFA model for the VLS-HSP scale, the researchers further applied the CFA to confirm the derived factor structure of the 30-item EFA model. After the CFA, the 30 items were reduced to 22, without removing any items in factor 1 (allegorical meaning); but removing items 7, 6, 8, 11, 1, and 10 in factor 2 (explicit meaning), and removing items 18 and 19 in factor 3 (symbolic meaning). Thus, the shorter CFA model included only 22 items: “allegorical” (12 items), “explicit meaning” (4 items), and “symbolic meaning” (6 items). However, with only 22 items in the CFA model, its total explained variance increased to 75.022%, compared to the 73.191% of variance in the 30-item EFA model.

Regarding the change in item factor loadings in the EFA and CFA models, based on Hair et al,<sup>28</sup> factor loading values bigger than 0.50 are taken as being sufficient and with values above 0.70 being good. In the EFA Model, the item factor loadings in the “allegorical meaning”, “explicit meaning”, and “symbolic meaning” subscales ranged between 0.510 and 0.983, all satisfying the critical value 0.50,<sup>28</sup> which means that these items are appropriate for measuring the factors. In the CFA model, with a removal of 8 items, the item factor loadings for the three subscales were increased and ranged between 0.823 and 0.923. Therefore, it can be implied that although the CFA model had less items, it had better factor loading values.

Regarding the goodness-of-fit of both the EFA and CFA models, it is shown (as in Table 5) that, the indices for the 30-item EFA model indicated acceptable model fits in terms of  $\chi^2/df$  ratio (3.145), TLI (0.907), CFI (0.9914), and

RMSEA (0.084); the indices for the 22-item CFA model also indicated acceptable or even excellent model fit in terms of  $\chi^2/df$  ratio (1.222), TFI (0.993), CFI (0.995), and RMSEA (0.027). While the researchers compared the good fit indices in the two models, it can be found that the 22-item CFA had better goodness-of-fit, with an increase in TLI and CFI of 0.086 and 0.081, and a decrease in  $\chi^2/df$  ratio of 1.923 and a decrease in RMSEA of 0.057.

While looking into the convergent validity of the 22-item CFA model, the AVE values of the “allegorical meaning”, “explicit meaning”, and “symbolic meaning” subscales are higher than the benchmark value 0.5, and the composite reliabilities of these three are higher than the benchmark value of 0.6. Moreover, the AVE values are lower than their corresponding composite reliability values. According to Fornell and Larcker’s set criteria about convergent validity,<sup>45</sup> the AVE value and the composite reliability value are required to be bigger than 0.5 and 0.6, respectively. Furthermore, the AVE values are expected to be lower than the corresponding composite reliabilities.<sup>28,34</sup> Hence, based on the research findings and Fornell and Larcker’s set criteria about convergent validity, it can be concluded that the 22-item CFA model had passed through the convergent validity examination.

Regarding the discriminant validities, Fornell and Larcker’s set criteria<sup>45</sup> indicated that  $\sqrt{AVE}$  for each factor should be greater than its correlation coefficients ( $r$ ) with any other factor. Hence, based on Fornell and Larcker’s set criteria, the results also confirmed the discriminant validity between “allegorical meaning” and “explicit meaning”, between “explicit meaning” and “symbolic meaning”, and between “symbolic meaning” and “allegorical meaning”.

As for the reliabilities, in both of the 22-item CFA model and 30-item EFA model, the Cronbach’s alpha and composite reliability values were all above 0.90, superior to the lowest acceptable reliability value of 0.70.<sup>28,34</sup> The findings also correspond to Cunha, Almeida Neto, and Stackfleth’s<sup>47</sup> set benchmark, indicating that a reliability above 0.70 is considered as a good level of reliability. Therefore, with higher reliabilities,<sup>40,41</sup> it can be concluded that both the 22-item CFA and 30-item EFA models for the VLS-HSP scales had high internal consistency reliabilities.<sup>28,29,43,47</sup> Compared with Arslan’s visual literacy levels scale,<sup>48</sup> a 41-item and 7-dimension scale, with Cronbach’s alphas for the subscales ranging between 0.753 and 0.861, the Cronbach’s alphas for the three subscales of the 22-item and 30-item VLS-HSP were all above 0.90. In addition, the total explained variance value of Arslan’s 41-item visual literacy levels scale was 57.201%; the total explained variance values of the 30-item and 22-item VLS-HSP in the study were 73.191%, and 75.022%, respectively, which are higher than the total explained variance value of Arslan’s visual literacy levels scale. Therefore, it can be concluded that the developed VLS-HSP scale has proved to be a better tool for assessing participants’ visual literacy.

To sum up, after the validity and reliability examinations, given these findings, both the 30-item EFA model and the 22-item CFA model for the VLS-HSP scale can be regarded as formal measures for assessing visual literacy in health students or people with health-related training or expertise. Although both the 30-item EFA and the 22-item CFA models can be taken as formal instruments for assessing visual literacy, there may be some limitations in the study because respondents may not give honest answers in the survey. Besides, the VLS-HSP scale was developed on the basis of Taiwanese cultural backgrounds to realize visual literacy in health students and professionals, for those who are interested in using the scale, they should consider their cultural backgrounds and the backgrounds of the respondents when translating the scale into their mother tongues so that the respondents can fully understand the items.

## Conclusion

The results of the study suggested that both the 30-item EFA model and 22-item CFA model for the VLS-HSP scales can serve as reliable and valid tools for measuring visual literacy in health students and professionals. Future research may consider developing teaching strategies and courses to develop visual literacy in medical and health care settings, and using both the long- and short-version scales to assess the outcomes of the courses and strategies, with the goal of facilitating communication among patients, patient families, and health providers.

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