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Instrument Development of Design Thinking Test for Graphic Design Students

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ABSTRACT

Objective: Design thinking is one of the methods used to carry out the design process. So, in solving this design problem, design students, especially Graphic Design students, should carry out the stages of design thinking for the work design process. The measurement of design thinking ability is a written exam to get a standardized assessment. This Research aims to describe the development of a design thinking test instrument for graphic design students. **Method:** The design thinking test instrument consists of 30 multiple-choice questions. After the questions were completed, five experts validated the question. The results of content validation to five experts were analyzed using the Content Validity Ratio. The question was then tested on 30 Unesa Graphic Design students. The results of each question item were tested for validity through the Rasch model with the STATA Program and ConQuest. **Results:** To test the reliability of the instrument using Cronbach Alpha. The result is CVR scoring between 0.500 and 1.000, and the alpha Reliability value exceeds 0.881. The results of the total item correlation test vary from -0.0391 to 0.465, while the INFIT MNSQ value of the Rasch model starts with a value of 0.500 to 1.300. **Novelty:** It is concluded that the written test assessment instrument is empirically valid, so the design thinking skills assessment instrument is feasible to use.

INTRODUCTION

The field of graphic design is broad; students are taught various types of projects, including advertising, publication, and visual communication, as well as the development of signage, displays, and typography. This diverse field requires designers to explore knowledge about different cultures in a project, so it takes creativity in the problem-solving abilities of graphic designers (Altan & Tan, 2021; Chang et al., 2022; Guaman-Quintanilla et al., 2023; Saris, 2020).

The novice graphic designers tend to immediately construct visual ideas when given a problem without further thinking about the goal. The role of design as problem-solving is closely tied to the designer's ability in the design thinking process (Balakrishnan, 2022; Calavia et al., 2021; Dell'Era et al., 2020; Lin et al., 2020). The design thinking process is a problem-solving method that emphasizes user focus. Through problem-solving, designers discover appropriate solutions and resolutions for their challenges. As a form of creative problem-solving, design thinking delves into inspiration, guiding the development of creative and original solutions to meet user needs (Dell'Era et al., 2020). Design Thinking may enhance collaborative problem-solving by promoting trust between participants, potentially increasing intrinsic motivation and, consequently, the quality of solutions generated. This effect warrants further investigation through empirical studies to establish causal relationships and

quantify the impact on solution quality (McLaughlin et al., 2022). So, in solving this design problem, the designer, in particular, should carry out the stages of design thinking for the design process. In the graphic design curriculum, the material for the design thinking process is included in the design methods course. The design method course explains the methods, procedures, and strategies for designing design projects based on the designer's thinking process and how designers think creatively in solving design problems based on previously studied design theories (Eklund et al., 2022; Klenner et al., 2022; Pratomo et al., 2021; Taneri & Dogan, 2021). The designer's thought process is conveyed through design thinking theory, which is applied to an idea to solve design problems.

Design thinking is an indispensable part of what goes through the designer's mind in every design project. It is a powerful thinking tool that can steer brands, businesses, or individuals in a positive direction. Design thinking is a fundamentally creative process driven by specific problems and individuals but goes beyond conventional solutions (Pressman, 2019). Design thinking begins with creative Research in action and ends with the realization of systems of various scales (Buchanan, 2019). Design thinking skills are crucial for graphic design students because they involve problem-solving, creativity, and innovation. Design thinking also helps design students become creative and highly motivated (Balakrishnan, 2021)

Design thinking is a methodology that provides a solution-based approach to solving problems. There are five stages in the model proposed by the Hasso-Plattner Institute of Design at Stanford. Critical elements in design thinking include being human-centered, fostering creative freedom, conducting trials with potential users, and iterating through specific stages repeatedly. The beginning of design thinking was the design company IDEO, with David Kelly as its founder and his brother Tom Kelly. Then In 2008 David Brown, as CEO of IDEO published an article in the Harvard Business Review to describe the Design Thinking approach of IDEO. It was designed to trigger creativity and collaboration in solving significant problems through a human-centered approach. The five stages of design thinking are empathizing, Defining, identifying, prototyping, and testing.

This Research to measure students' design thinking abilities that have been conducted takes the form of a case study research involving observations of a group of students as they work on a design project. The measurement of cognitive design thinking abilities has been researched using various analysis techniques, including black box experiments and protocol analysis. Students are presented with a design brief, and their behaviors are observed based on specific instruments (Gero & Milovanovic, 2020).

Measuring the design thinking abilities of students through written exams has yet to be conducted among design students in Indonesia. An exam is an assessment procedure carried out by instructors to evaluate students' knowledge and skills, determining their performance using specific instruments (Oguguo et al., 2021; Sailer et al., 2021; Urhahne & Wijnia, 2021; Wilson & Narasuman, 2020). The mentioned instruments vary, ranging from sets of questions to be answered or tasks involving the creation of a specific product. Exams can take various forms intended to provide an objective measurement of the learning activities that have been undertaken. The most common form of exam or test used by instructors to assess students in the classroom is a written test.

Developing assessment instruments is an effort to create assessment tools based on needs analysis, which becomes newly tested assessment instruments. Thus, an

instrument for measuring students' design thinking skills generates a functional and beneficial assessment instrument. Assessment instruments are used to gauge the design thinking skills of Graphic Design students, requiring assessment. This assessment employs a testing method, hence the need for assessment instruments in the form of questions. As an instrument of measurement, assessment instruments need to undergo validity and reliability testing to measure their validity and reliability. Instruments that meet validity and reliability standards can be used for the measurement phase (Azwar, 2019).

Based on the previous problem background, the author strives to develop an assessment instrument to determine the design thinking skills of graphic design students. Therefore, this Research aims to describe the procedure of constructing a test instrument and to depict the process of validating and ensuring the reliability of the graphic design students' assessment (Munna & Kalam, 2021).

This Research introduces a novel contribution to the field by developing a specific instrument to assess design thinking ability among students enrolled in graphic design study programs. This innovative approach distinguishes itself by adopting Hasso Plattner's design thinking process into a test that assesses the student's ability to understand the design thinking process itself. By employing this multifaceted approach, the Research offers a comprehensive and nuanced understanding of how Graphic Design students in vocational settings approach the creation ventures in design thinking.

RESEARCH METHOD

Research Procedure

This type of Research is Research and development. Development research is oriented towards creating and validating products used in education. This Research refers to Research and development that encompasses three stages: 1) The preliminary stage involves determining the location and subjects for conducting the Research. 2) The self-evaluation stage consists of student analysis, curriculum analysis, and analysis of the developed tools or materials. Next, designing the developed tools, including outlines, objectives, and the developed methods. 3) The prototyping stage (validation, evaluation, and revision). The designed product is then evaluated through testing with Expert Review and Small Group sessions (Tessmer, 1994).

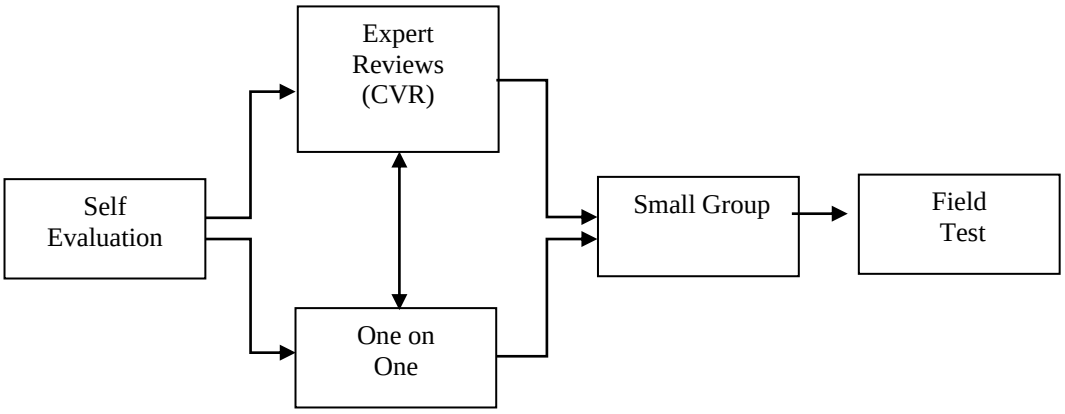

Figure 1. Design of formative evaluation design.
(Source: Tessmer, 1993)

Question Trials

The test subjects in this development research are 40 students from the Graphic Design Study Program at Unesa. The quantitative data used includes questionnaire results filled out by validators to test the content validity of the developed questions and student scores obtained after testing the product. The data analysis technique employed in this Research involves non-dichotomous instrument testing, content validity testing for questions and items, and question reliability.

Content validity is a qualitative form of validity that judge whether the statement carried in the measuring instrument depicts the phenomenon that will be measured (Sürücü & Maslakçı, 2020). Content validity means that a test should be comprehensive in its content and include items relevant to the measurement objectives (Azwar, 2019; Creswell & Creswell, 2018). Experts in the domain of interest must make content valid. The content validity of the questions is tested using the content validity ratio (CVR) approach, which questions the alignment between the test's question items and the description of the taught material.

A question item is considered to have content validity when it measures a specific objective that aligns with the subject matter or content provided. The content validity of a question item is determined using the CVR developed by Lawshe. CVR is one of the approaches used to measure content validity based on the assessment results of validators. Validators are subject matter experts who answer questions for each item, ensuring that the item has sufficient content validity. Validators assess on a Likert scale of 1-4. CVR uses Lawshe's formula, resulting in a range of values from -1 to +1. Positive values indicate that at least half the validators rate the item as important/essential. The larger the CVR value is above 0, the more "important" and higher the content validity becomes. The second question item validation is item-rest correlation, used to determine the relationship between an item and the total score of other items. Higher item-rest correlations result in higher coefficients in test outcomes. The minimum required value for item-rest correlation is 0.20 for maximum performance tests. The analysis of item-rest correlation uses the STATA program.

The fit test for each assessment item is performed using the Rasch Model Item Response. The Rasch model, also known as a one-parameter model, is used to analyze data that focuses solely on the difficulty parameter of the items. The Rasch model provides a rigorous framework for test evaluation. It analyzes inter-rater variability and item difficulty, which comprehensively assesses measurement instrument validity and reliability (Avinç & Doğan, 2024). Things that deal with latent traits use Item Response Theory (Arifin, 2021). The Rasch model is part of IRT (Item Response Theory), where reliability in the context of IRT/Rasch varies between different ability levels. The Rasch model concurrently estimates the latent traits of respondents (persons) while identifying response patterns. This allows for detecting systematic bias (agreement) and random responses within an attitude instrument (Irmayanti et al., 2023). The same test will yield different measurement reliabilities for individuals with very high and meager abilities. Reliability values in the Rasch modeling are indicated by individual separation and item separation. Individual separation indicates how well a set of items in the test is spread across the range or continuum of logit abilities (Joshi et al., 2020).

The analysis programs used for the Rasch model usually report the fit statistics as two chi-square ratios, called the Infit MNSQ and Outfit MNSQ statistics (Tunç, 2023). The Mean-Square Fit Statistic (MNSQ) reflects how well an item in a Rasch model

aligns with the model's expectations (Wolniak, 2023). It is calculated by averaging the squared standardized residuals from each respondent's answer (N observations). Essentially, it is a chi-square statistic adjusted for degrees of freedom. Ideally, an MNSQ value close to 1 indicates a good fit between the item and the Rasch model (Tesio et al., 2024). INFITMNSQ value falls within the range of 0.600 to 1.400. Items falling within this range can be used to measure Graphic Design students' design thinking skills.

The instrument's reliability test calculates the reliability of the student's test using Cronbach's Alpha. Since respondents only attempt the test once, the reliability test employs an internal consistency approach. Reliability is determined by the value of the reliability coefficient (Azwar, 2019). This reliability test uses the STATA program. The reliability criterion for the instrument is a minimum reliability coefficient of 0.600.

RESULTS AND DISCUSSION

Results

Self Evaluation

The researcher analyzed students, the curriculum, and the developed tools, then designed the developed tools, which included constructing question blueprints based on question indicators according to Bloom's cognitive taxonomy levels. The design thinking assessment instrument consists of multiple-choice questions to assess the design thinking skills of Unesa's graphic design students. The question items are based on four out of five design thinking processes, with the details of the question blueprint as in Table 1.

Table 1. Measurement indicators for design thinking skills.

Design Thinking	Description	Indicator	Question Number
Empathize Skills	Empathy means designers need to consider the feelings of the audience as the target (Tsai & Wang, 2020)	Able to understand the perspectives and feelings of the audience in creating artwork.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
	is a skill to develop and portray a general perspective of a problem based on what is experienced, collaboration, and the way of thinking (Pande & Bharathi, 2020)	Able to describe problems.	12, 13, 14, 15, 16, 17, 18, 19
Define Skills	is a skill in clearly identifying user needs or problems (Tsai & Wang, 2020)	Able to identify user needs.	20, 21, 22, 23, 24
	It is the ability to leverage existing knowledge to drive new learning (Pande & Bharathi, 2020).	Able to utilize knowledge.	
Ideate Skills	is a skill to use brainstorming and generate various creative solutions	Able to generate various solutions through brainstorming while creating.	25, 26, 27
	It is the skill to produce fresh ideas (Pande & Bharathi, 2020).	Able to generate numerous fresh ideas.	
Prototype Skills	It is a skill to present initial ideas and display models for a problem-solving solution (Tsai & Wang, 2020).	Able to showcase applied ideas.	28, 29 30

Design Thinking	Description	Indicator	Question Number
	It is a skill to adapt between contexts and concepts (Pande & Bharathi, 2020).	Able to adapt between contexts and concepts.	

Prototyping

Lynn (1986) states that experts used for expert judgments are between 3-10 persons (Net et al., 2024). The results of the content validity analysis of the design thinking skills assessment instrument were carried out by five experts (expert judgment). The results of the content validity analysis of the design thinking skills assessment item questions conducted by five experts on 30 item questions of the assessment instrument ranged from a minimum value of 0.500 to a maximum value of 1.000. The range of values still meets the standards specified by CVR, which lies within the range of -1 to +1 (Table 2).

Table 2. CVR analysis and item rest correlation results.

	Item	CVR	Item Rest Cor	Suggestion
Emphasize	1	1.000	0.226	Restrained
	2	1.000	0.090	Revised
	3	1.000	0.237	Restrained
	4	1.000	0.140	Revised
	5	1.000	0.235	Restrained
	6	0.500	0.037	Revised
	7	1.000	0.240	Restrained
	8	1.000	0.082	Revised
	9	1.000	0.265	Restrained
	10	0.500	0.303	Restrained
	11	1.000	-0.026	Revised
	12	1.000	0.144	Revised
	13	1.000	0.178	Revised
	14	0.500	0.072	Revised
	15	1.000	0.104	Revised
Define	16	1.000	0.238	Restrained
	17	1.000	0.296	Restrained
	18	0.500	0.161	Revised
	19	0.500	0.366	Restrained
	20	1.000	-0.039	Revised
	21	1.000	0.103	Revised
	22	1.000	0.248	Restrained
Ideate	23	1.000	0.205	Restrained
	24	1.000	0.028	Revised
	25	1.000	0.050	Revised
	26	1.000	0.189	Revised
	27	1.000	0.412	Restrained
Prototype	28	1.000	0.465	Restrained
	29	1.000	-0.032	Revised
	30	1.000	0.348	Restrained

Based on the item-rest correlation test results in the measurement instrument for Graphic Design students' design thinking skills (Table 2), the lowest item-rest correlation value is -0.039 for item 20, and the highest value is 0.460 for item 29.

Table 3. Summary of item rest correlation test results.

	Question item
Below 0.200	2, 4, 6, 8, 11, 12, 13, 15, 18, 20, 21, 24, 25, 26, 28.
Above 0.200	1, 3, 5, 7, 9, 10, 14, 16, 17, 19, 22, 23, 27, 29, 30,

Based on the values obtained from the outfit (Unweighted Fit) item test, the highest value was recorded for item dtt5 with a score of 1.040, and the infit (Weighted Fit) value was 1.030. On the other hand, the lowest values were for item 22, with an outfit (Unweighted Fit) value of 0.950 and an infit (Weighted Fit) value of 0.970. This indicates that all item questions have values ranging between 0.600 and 1.400, implying that all the question items are beneficial for measuring Unesa's graphic design students.

Table 4 Fit test results.

	Item	**Outfit (Unweighted Fit)**	**Infit (Weighted Fit)**
Empathize	1	1.010	1.010
	2	1.020	1.020
	3	1.030	1.010
	4	1.000	0.990
	5	1.040	1.030
	6	1.010	1.010
	7	0.980	1.000
	8	0.970	0.990
	9	0.980	0.980
	10	0.980	0.980
	11	1.010	1.010
	12	0.980	0.990
	13	0.960	0.980
	14	1.040	1.020
	15	1.020	1.010
Define	16	1.010	1.010
	17	0.980	0.980
	18	0.980	0.990
	19	1.020	1.010
	20	1.030	1.020
	21	1.000	1.000
	22	0.950	0.970
Ideate	23	1.020	1.020
	24	0.970	0.980
	25	1.040	1.020
	26	0.990	1.000
	27	0.970	0.980
Prototype	28	0.980	0.990
	29	1.000	1.000
	30	0.990	0.990

Based on the item-rest correlation test, there are 14 item questions with values below 0.200, which indicates that these items should be revised. However, considering the results of the analysis of design thinking skills using the Rasch IRT model, these 14-item questions still fall within the range of 0.600 to 1.400. Therefore, these 14-item questions can remain and should not be revised. Lastly, The test result of Cronbach's Alpha test is 0.616.

Table 5. Comparing item rest cor and fit test results.

	Item	Item Rest Cor	Outfit (Unweighted Fit)	Infit (Weighted Fit)	Recommendation
Empathize	2	0.090	1.020	1.020	Restrained
	4	0.140	1.000	0.990	
	6	0.037	1.010	1.010	
	8	0.082	0.970	0.990	
	11	-0.026	1.010	1.010	
	12	0.144	0.980	0.990	
	13	0.178	0.960	0.980	
	14	0.072	1.040	1.020	
	15	0.104	1.020	1.010	
Define	18	0.161	0.980	0.990	Restrained
	20	-0.039	1.030	1.020	
	21	0.103	1.000	1.000	
Ideate	24	0.028	0.970	0.980	Restrained
	25	0.050	1.040	1.020	
	26	0.189	0.990	1.000	
Prototype	29	-0.033	1.000	1.000	Restrained

Discussion

Content validity can be accomplished by administering a questionnaire to experts in the field that has a relevant domain, including assessment experts, learning experts, design experts, and design learning experts (Khidhir & Rassul, 2023). The prototyping results from 5 expert judgments validated 30 questions, and the values by CVR were met. Therefore, all 30-item questions of the design thinking skills instrument are suitable, and further validity and reliability tests can be conducted.

On item-test correlation test (Table 3). There are 16 out of 30 item questions with values below 0.200, which suggests they should be revised. The remaining 14 item questions have values above 0.200, indicating that these questions are appropriate and should be retained. The Unweighted Fit item test indicates that all item questions have values ranging between 0.600 and 1.400, implying that all the question items are beneficial for measuring Unesa's graphic design students. The final questions can then be used to measure the broader design thinking skills of Unesa's graphic design students.

The reliability test of the design thinking skills assessment instrument employs Cronbach's Alpha. The instrument is considered reliable if the alpha value is > 0.600 (Kennedy, 2022). Thus, with 0.616, Cronbach's Alpha shows that the measurement instrument is reliable for assessing the design thinking skills of graphic design students. It is important to note that Cronbach's Alpha assumes all the items are a single construct. Hence, if the scale contains multiple dimensions, it may lead to inaccuracy of the instrument. The item similarity may also influence it.

CONCLUSION

Fundamental Finding: The assessment instrument for design skills in multiple-choice questions is deemed suitable based on the content validity score from five expert assessments, with CVR scores ranging between 0.500 and 1.000 for each question item. From the item-rest correlation test results, scores vary between -0.039 and 0.465. Meanwhile, the INFIT MNSQ values from the Rasch model range from 0.500 to 1.500. **Implication:** The questions are also deemed reliable, with an alpha reliability value exceeding 0.600. **Limitation:** However, the tests used have limitations, especially if the data showcase multidimensional characteristics.

In conclusion, the empirical evidence shows that the written test assessment instrument is valid. Thus, the design thinking skills assessment instrument is suitable for use as it fulfills the requirements of content validity, empirical validity, and reliability aspects. **Further Research:** Additional Research is needed to further test the design thinking assessment questionnaire using larger sample sizes or with different students from various universities.

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