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Development of Airfield Lighting System Digital Learning Media: An Application Usability Testing

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Abstract: This study aims to evaluate the usefulness of a game-based learning tool called the airfield lighting system that uses both VR and AR technology in the classroom. The quantitative research method uses a survey to gather data and test the application in two classes. The application's usability is represented by data analysis that uses the User Experience Questionnaire (UEQ) model to quantify two aspects: hedonic and pragmatic quality. The study's findings display the means of the positive value scales, indicating that the pragmatic quality score was 2.538 and the hedonic quality score was 2.548. In addition, To gain a more comprehensive understanding of a product's quality, we also assess the product's measured user experience by contrasting it with the outcomes of other well-known products. The results are interpreted within the 10 percent best results range, indicating "excellent" for five instruments and "above average" for novelty instruments. The result presents six instruments of usability level: efficiency, perspicuity, dependability, stimulation, and novelty. This usability test suggests using the airfield lighting system application as the learning medium for student-centered learning.

Keywords: Airfield Lighting, Learning Media, UEQ, Usability Test, User Experience

A. Introduction

Enhancing learning and learning outcomes is the goal of educational technology (Puentedura, 2006). The numerous digital learning media innovations employed in education today demonstrate the importance of information technology in education (Du Toit & Verhoef, 2018; Hashim, 2018). It is also predicted that the benefits of digital learning media in the form of learning applications will boost students' motivation, independence, and aptitude for learning (Shenkoya & Kim, 2023). Another reason for the increased use of technology in education, particularly in Indonesia, is the COVID-19 epidemic era (Elnasr et al., 2020; Schleicher, 2020). The internet has finally started to touch education, which has not yet been fully impacted by technology. Internet-based learning programs make it easier for lecturers to deliver content while keeping track of student progress and evaluation and help lecturer to increase the pedagogic skill (Komalasari et al., 2023). As said in (Coman et al., 2020; Omar et al., 2019; Yang &

Cornelious, 2004), because a learning media application is more flexible and can be used anytime, it creates a refreshing learning environment for students. It increases their motivation to learn on their own. Virtual reality (VR) and augmented reality (AR), which were first applied to games (Lazo-Amado et al., 2022), commerce and sales (Kassim & Bakar, 2021), and health, are now being used more and more in education. Numerous studies have shown that the use of VR and AR in education has been beneficial (Elmqaddem, 2019; Excellence et al., 2017; Motejlek et al., 2019; Roda-Segarra et al., 2022). AR and VR in medicine are used for back pain simulation (Stamm et al., 2022), and to help residents get to know neurosurgeons(Pelargos et al., 2017). VR is also used in art instruction in 2021 and the nursing curriculum (González-Zamar & Abad-Segura, 2020; Saab et al., 2021). Weather simulators and robotics learning media use AR and VR, particularly as simulators (Indryani et al., 2022; Noueihed et al., 2022).

Vocational higher education must keep up with advances in science and technology in the workplace and match its graduates' competency and certification requirements in the age of technological disruption and digital revolution (Nugraha et al., 2023). Digital learning media needs to be appropriate for the needs that reflect the learning objectives as well as the characteristics of the learners (Zhu et al., 2021). Politeknik Penerbangan Palembang is concerned with enhancing education quality, which has been proven by implementing MOOCs as a learning platform linked to an x-ray simulator (Yuniar et al., 2023) and it is concerned with implementing a project-based learning system (Suryan et al., 2023). The 70 percent practice and 30 percent theoretical airfield lighting system (ALS) course aims to help cadets comprehend the many kinds of airfield lighting equipment. The learning materials for this sort of program are designed to simulate an airport visit for the cadets. A portable wind direction indicator has already been developed as a learning medium in research (Soleh et al., 2023). The application's use of VR is anticipated to deliver this experience. The AR component built into this airfield lighting system application is expected to deliver a three-dimensional depiction of each airfield lighting procedure. Additionally, pop-up information on each piece of equipment is displayed when the program is clicked. We used Unity 3D, a program frequently used for 3D game production, to create this game-based learning application (Cheliotis, 2021; Wang & Zeng, 2019). It is anticipated that cadets will learn the airfield lighting system more quickly and enthusiastically due to the construction of this simulation game-based learning resource (N.K.S. Widarini et al., 2021; Ullah et al., 2017).

The steps of 4D models (Hariyanto et al., 2022) to develop the application have been executed. A field test phase of the DIV-TRBU Study Program has been conducted on a single class. Cadets can effortlessly install the application on their computer or mobile phone, the pre-test is accomplished, installation and usage instructions are presented, and group testing of the program follows as learning activities. We have confirmation of the cadets' enthusiasm based on field observations. The cadets' faces showed expressions of awe and excitement in the application. These results demonstrated that using VR and AR in education can help improve mood, student-teacher engagement, and motivation for more effective student-centered learning (Amalia & Nugraha, 2021; Björn, 2022; Khan et al., 2019).

Two aspects become a measure that users can run and accept an application. First, User Interface (UI), where UI or user interface is everything that comes into direct contact with the user's eyes or that they use to interact with an application or system. So, UI emphasizes the visual and interactive aspects of design involving elements such as color, typography, buttons, icons, and other visual elements that make up the interface's appearance (Schölkopf et al., 2022). Second, User Experience (UX) covers all aspects of user interaction with a product or service, including its emotional and psychological aspects (Lallemand et al., 2015). UX considers the entire user journey, from start to finish, and involves aspects such as user satisfaction, effectiveness, efficiency, and the overall quality of the user experience. It must be considered before implementing an application or making product revisions. While both are intertwined and mutually supportive, they are distinct concepts in holistic user experience design. A good product or application must balance an attractive UI and a satisfying UX. Through UX testing, it is expected to measure 1) the level of user satisfaction with the experience of using the product or application, 2) ensure that users can achieve their goals by using the product or application without significant difficulties, 3) assess the extent to which users can complete their tasks quickly and without unnecessary obstacles, 4) measure how quickly new users can understand how to use the application or product, 5) check the extent to which users can remember how to use the application after some time without using it, 6) ensure that the application is accessible to various user groups, including those with accessibility challenges, 7) collect user feedback to gain insight into improvements that may be needed at the user experience level.

There are several models for usability testing, among which the most popular are USE Questionnaire testing and User Experience questionnaire (UEQ) testing. USE Questionnaire has four aspects: Usefulness, Ease of Use, Ease of Learning, and Satisfaction while UEQ has four aspects of assessment: Attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty. Judging from the aspects assessed by the USE questionnaire, the aesthetic aspects and fun assessment are not included. Meanwhile, the UEQ has been included, and another added value is that UEQ has prepared a data processing tool so that, as a user, UEQ covers everything needed in testing this airfield lighting system. Because of learning media and increasing learning efficiency, we must also increase learning efficiency, including motivation and interest to use the application. Based on the above considerations, we will use the UEQ model to analyze the survey results for a more complete assessment. Some previous research related to the use of UEQ in user experience testing of leading applications, such as (Fadillah et al., 2022) which uses UEQ with a 24-question scheme to determine the UX assessment of the AR Organology application, which is an AR Organology application which is an application that studies the digestive and respiratory systems in humans.

Research (Pratama et al., 2022) also used the UEQ with 24 questions, as did (Alawiyah & Canta, 2022). This research shows that UEQ has proven to be a tool for measuring complete user experience aspects. On average, new application testing will use 24 UEQ question items. Still, for this research, we will use the UEQ Short Version, which consists of eight questions, to minimize time, ambiguity, and errors in data processing results. The aims of this research are 1) testing the usability or user experience of the airfield lighting system as a digital learning media using the UEQ model, 2) knowing the six aspects of user experience assessment, including Attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty, 3) benchmarking similar applications that have been developed previously using the UEQ software database list. The results of this test can be used as recommendations for future product development so that product development can look more at the users' needs.

B. Methods

This study aims to measure the usability of airfield lighting system learning media, a game-based learning media with augmented reality (AR) and virtual reality (VR) technology implemented in the class using the UEQ Model. This research was conducted in DIV-TRBU, Politeknik Penerbangan Palembang, with object cadets of TRBU in the 2nd and 3rd class a sample. The research method used in this study is quantitative, data collection by survey share after field testing and data analysis using UEQ model.

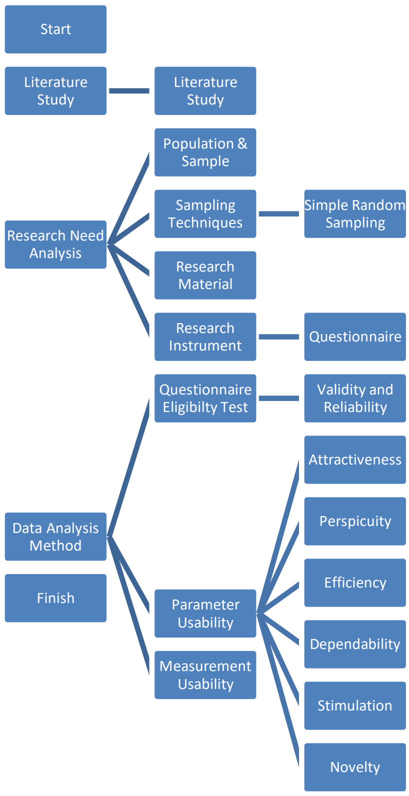


Figure 1. Research Steps

The literature study collects and reviews literature based on the research theme to get the theoretical basis. The literature source is an article and book provided from the internet. *Research needs analysis* using DIV TRBU Cadet as population, with sample to 2nd and 3rd grade class cadets. Referring the slovin formula, $n = N/(1+N(e)^2)$, where total population of cadets are 92, so the samples become 48 cadets. The research instrument uses 26 UEQ with a 7-stage scale to reduce well-known central tendency bias for such item types. The items are scaled from -3 to +3. Thus, -3 represents the most negative answer, 0 is a neutral answer, and +3 is the most positive answer. A questionnaire eligibility test of UEQ scales, both validity and reliability tests, was developed by the UEQ team, the results of which show a sufficient and high consistency using Cronbach's Alpha (Laugwitz et al., 2008; Schrepp et al., 2017a). The question list used are based on UEQ list of question, as shown below.

Table 1. UEQ Questionnaire

Aspects	Instruments	List of Question
Attractiveness		Annoying/enjoyable
		Bad/good
		Unlikable/pleasing
		Unpleasant/pleasant
		Unattractive/attractive
		Unfriendly/friendly
Pragmatic Quality	Efficiency	Show/fast
		Inefficient/efficient
		Impractical/practical
		Cluttered/organized
	Perspicuity	Not understandable/understandable
		Difficult to learn/easy to learn
		Complicated/easy
		Confusing/clear
	Dependability	Unpredictable/predictable
		Obstructive/supportive
		Not secure/secure
		Doesn't meet expectations/meet expectations
Hedonic Quality	Stimulation	Inferior/valuable
		Boring/exciting
		Not interesting/interesting
		Demotivating/motivating
	Novelty	Dull/creative
		Conventional/inventive
		Usual/leading edge
		Conservative/innovative

The sampling technique in this study refers to cadets who already have airfield lighting classes. An instrument chosen as a measuring tool uses quantitative information to represent the characteristic. Questionnaire use is based on the UEQ model, which represents Attractiveness that depends on two quality levels: hedonic and pragmatic quality, which contain six parameters: efficiency, perspicuity, dependability, stimulation, and novelty. Questionnaire eligibility test using validity test to ensure the instrument valid and reliable. Usability measurement has implemented with several stage: questionnaire selection, selecting participants, determining sample size, implementation. Values between -0.8 and 0.8 represent a more or less neutral evaluation of the corresponding scale, values > 0,8 represent a positive evaluation and values < -0,8 represent a negative evaluation. The range of the scales is between -3 (horribly bad) and +3 (extremely good). But only values in a restricted range will be observed in real applications.

C. Results and Discussion

Usability measurement starts with distributing 26 lists of UEQ questions to 48 respondents who have already been tested to see the feasibility—the characteristics of the respondents are classified based on gender and age.

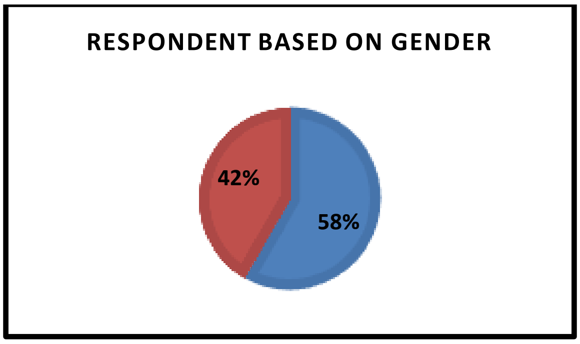


Figure 2. Respondents classified by gender

The total number of respondents is 48 cadets, with 42% or 20 male cadets (red area) and 58% or 28 female cadets (blue area).

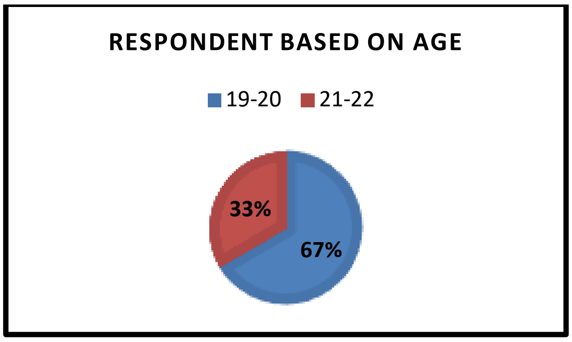


Figure 2. Respondents classified by age

The respondent's age can be seen in the figure below. Respondents total 32 cadets with the age of 19-20 years old (blue area), and 16 cadets with the age of 21-22 years old (red area).

Transformed Data

The questionnaire randomly arranges the positive and negative terms for each item. Half of the elements in each dimension begin with a positive phrase, while the other half have a negative one. The modified values for each item are available here. For this airfield lighting system application, statistical computations, we utilized these values. The scale for the items is -3 to +3. Hence, the most negative answer is represented by -3, the most positive by +3, and the neutral response by 0.

Table 2. Transformed Data Value

Items																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
2	3	2	3	2	2	2	2	2	1	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	-3	3	3	3	3	3	3	3	3	3	3	-3
3	3	2	3	3	1	2	-2	2	2	1	3	1	2	2	2	2	1	2	2	1	2	2	1	1	2
2	2	0	2	1	0	0	2	2	1	1	3	3	1	2	2	3	0	3	3	3	2	2	0	1	0
2	-1	0	-1	2	0	1	1	2	0	1	2	1	1	0	1	2	1	2	2	1	2	2	1	1	0
-1	2	2	-3	0	0	0	2	2	0	0	0	0	-1	0	-1	-1	-1	0	0	2	2	2	0	1	2

Scale means per person					
Attractiveness	Perspicuity	Efficiency	Dependability	Stimulation	Novelty
1,83	2,25	2,00	2,00	2,00	1,50
3,00	3,00	3,00	3,00	3,00	0,00
2,00	2,00	2,00	0,75	1,75	2,00
1,50	2,50	2,25	2,25	0,25	0,75
1,33	0,00	2,00	1,50	1,00	0,00

Confidence Interval for Items and Scales

The means of the scale and the individual items are displayed here, along with their respective 5 percent confidence intervals. A gauge of the accuracy of the scale mean estimation is the confidence interval. These results can be trusted more because of the increased estimation precision and smaller confidence interval. The quantity of data provided and the consistency with which the individuals assessed the examined product determine the width of the confidence interval. The lower the confidence interval, the more consistent their judgment is.

Table 3. Confidence Interval Items and Scale

Confidence interval (p=0.05) per item						
Item	Mean	Std. Dev.	N	Confidence	Confidence interval	
1	2,739	0,511	92	0,104	2,635	2,843
2	2,761	0,521	92	0,107	2,654	2,867
3	-2,804	0,474	92	0,097	-2,901	-2,707
Until…						
26	2,283	1,592	92	0,325	1,957	2,608

Confidence intervals (p=0.05) per scale						
Scale	Mean	Std. Dev.	N	Confidence	Confidence interval	
Attractiveness	2,725	0,503	92	0,103	2,622	2,827

Perspicuity	2,505	0,739	92	0,151	2,354	2,657
Efficiency	2,704	0,542	92	0,111	2,593	2,815
Dependability	2,492	0,652	92	0,133	2,359	2,625
Stimulation	2,628	0,698	92	0,143	2,485	2,770
Novelty	1,101	0,672	92	0,137	0,963	1,238

The Cronbach-Alpha (Bonett et al., 2014) coefficients ($n * r/1 + (n-1) * r$), for each of the six UEQ scales are displayed on one of the Excel-spreadsheets. Tool's Here, r denotes the mean correlation of the scale's items, and n represents the scale's item count. A scale's consistency is measured by its alpha coefficient, which shows that every item on the scale measures the same concept. The appropriate value of the Alpha-Coefficient is not well-defined. Values >0.6 or >0.7 are regarded by certain general guidelines as a sufficient level. It is advisable to read a scale with caution if its Alpha-Value is excessively small.

Distribution of Answers per Item

The distribution of responses to the individual items is shown here. It may be possible to gain deeper insights into aspects of the product that are perceived as highly positive by one participant subgroup and as highly negative by another subgroup if there are items in the survey that exhibit polarization in the responses.

Table 4. Distribution of answer per item

Nr	Item	1	2	3	4	5	6	7	Scale
1	annoying/enjoyable	0	0	0	0	3	18	71	Attractiveness
2	not understandable/understandable	0	0	0	0	4	14	74	Perspicuity
3	dull/creative	77	12	3	0	0	0	0	Novelty
4	difficult to learn/easy to learn	7	4	3	0	1	13	64	Perspicuity
5	inferior/valuable	4	4	0	1	0	5	78	Stimulation
6	boring/exciting	1	0	0	0	2	23	66	Stimulation
7	not interesting/interesting	0	0	0	0	1	25	66	Stimulation
8	unpredictable/predictable	4	1	2	12	8	15	50	Dependability
9	slow/fast	1	1	0	0	6	14	70	Efficiency
10	conventional/inventive	3	4	3	4	1	9	68	Novelty
11	obstructive/supportive	0	0	0	0	2	19	71	Dependability
12	bad/good	0	1	0	0	1	19	71	Attractiveness
13	complicated/easy	0	0	1	3	0	26	62	Perspicuity
14	unlikable/pleasing	0	0	0	0	0	22	70	Attractiveness
15	usual/leading edge	0	0	0	0	3	20	69	Novelty
16	unpleasant/pleasant	0	0	0	0	0	19	73	Attractiveness
17	not secure/secure	1	2	0	0	4	13	72	Dependability
18	demotivating/motivating	0	1	0	0	4	12	75	Stimulation
19	does not meet expectations/meets expectations	0	1	0	0	1	16	74	Dependability
20	inefficient/efficient	0	0	0	0		25	67	Efficiency

21	confusing/clear	0	2	0	0	4	14	72	Perspicuity
22	impractical/practical	0	0	0	0	1	21	70	Efficiency
23	cluttered/organized	0	1	0	0	2	15	74	Efficiency
24	unattractive/attractive	0	1	0	3	6	9	73	Attractiveness
25	unfriendly/friendly	0	1	0	0	2	17	72	Attractiveness
26	conservative/innovative	5	3	0	0	1	9	64	Novelty

We then see the question related to novelty: "dull/creative." I have negative impressions, but other questions regarding novelty such as: slow/fast, usual/leading edge, conservative/innovative has a highly positive answer. Clearer picture of this distribution of answer can be shown below.

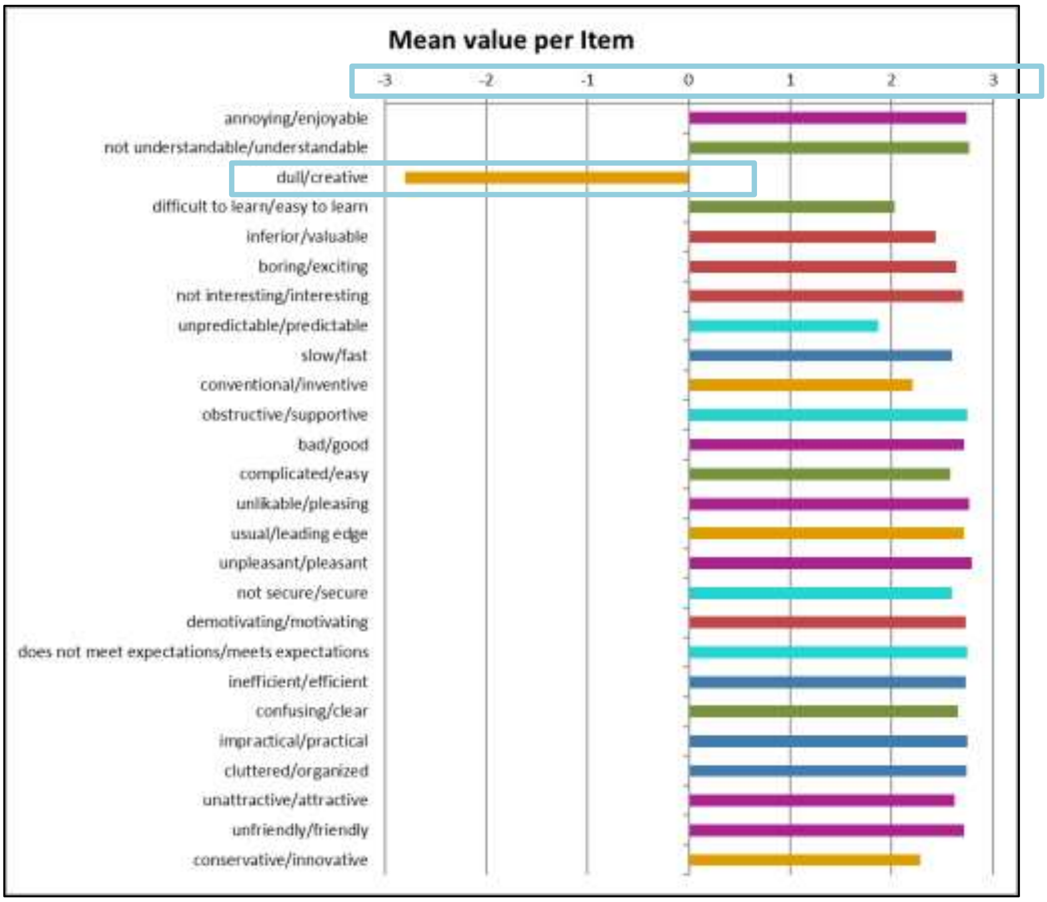
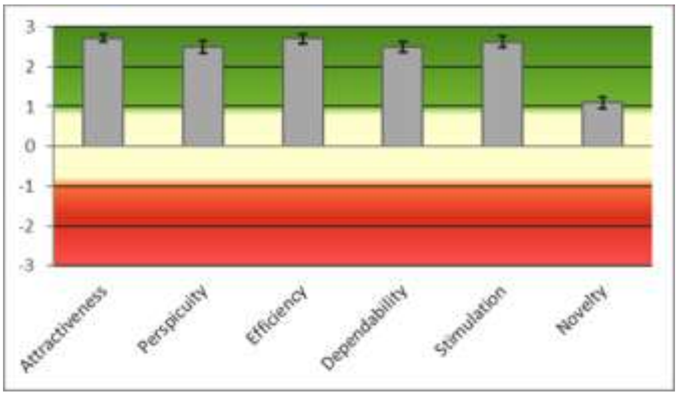


Figure 3. Mean value per item

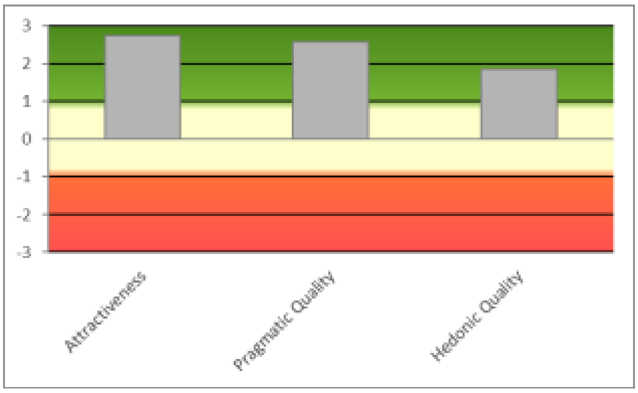
It is evident that every scale displays a very high rating in this case. Values between -0.8 and 0.8 indicate a neural evaluation of the corresponding scale, values > 0,8 indicate a positive evaluation, and values < -0,8 indicate a negative evaluation, according to the traditional interpretation of the scale. The scales' range is -3 (very poor) to +3. (extremely good). Nonetheless, only numbers inside a specific range will often be seen in real-world applications.



UEQ Scales (Mean and Variance)		
Attractiveness	2,725	0,25
Perspicuity	2,505	0,55
Efficiency	2,704	0,29
Dependability	2,492	0,43
Stimulation	2,628	0,49
Novelty	1,101	0,45

Figure 4. UEQ Result based on six usability instruments

The pragmatic quality (Perspicuity, Efficiency, Dependability) and hedonic quality scales of the UEQ can be combined (Stimulation, Originality). Hedonic quality refers to the non-task-related components of quality, while pragmatic quality describes work-associated quality aspects. The mean of the three pragmatic and hedonic quality aspects is computed below.



Pragmatic and Hedonic Quality	
Attractiveness	2,72
Pragmatic Quality	2,57
Hedonic Quality	1,86

Figure 5. Results categorized by three main aspects of usability

Because the means are calculated over various individuals with varying perspectives and answer preferences, the result values above +2 are unlikely to occur. They stay away from extreme answer categories, for instance. Therefore, to get a more precise evaluation of a product's quality, it is necessary to compare its user experience with the results of other popular products, like those from a benchmark data collection consisting of vastly different typical products.

Benchmark

Benchmarking means comparing the results for the evaluated product with the data in the benchmark, allowing conclusions about the relative quality of the evaluated product compared to other products (Schrepp et al., 2017a). The graph, which displays the mean scores for each scale, is handy for determining the degree of accuracy of a score relationship with a benchmark category.

Table 5. Airfield lighting system benchmark result

Scale	Mean	Comparisson to benchmark	Interpretation
Attractiveness	2,72	**Excellent**	In the range of the 10% best results
Perspicuity	2,51	**Excellent**	In the range of the 10% best results
Efficiency	2,70	**Excellent**	In the range of the 10% best results
Dependability	2,49	**Excellent**	In the range of the 10% best results
Stimulation	2,63	**Excellent**	In the range of the 10% best results
Novelty	1,10	**Above Average**	25% of results better, 50% of results worse

From the calculation above, the results of benchmarking the airfield lighting system have a good value, with "excellent" scale attractiveness, perspicuity, efficiency, dependability, and stimulation. This result can be interpreted as the airfield lighting system already in the range of the 10% best result compared to a similar product. The result is "above average" reached by the novelty scale, which means the airfield lighting system is in the middle, with 25 % of the result in the data set better than the airfield lighting system but 50 % worse.

From the result above, we can add some discussion which leads to one question, "What needs to be altered to enhance the product's user experience?". It is impossible to answer this question directly using a quantitative user experience measurement. Tying the measurement to the product features is necessary to respond to this question. Still, it is possible to estimate which areas will benefit most from reforms with a questionnaire such as the UEQ (Lasawali et al., 2022; Pratama et al., 2022). The UEQ displays a pattern of six assessed user experience qualities for an evaluated product as stated in (Fauzi et al., 2021). It is possible to infer at least some information about where to look for improvements from this pattern. The result and benchmark are not usually having a good result as stated in (Herdianingsih & Cahya, 2023). Complete scales can be excluded from the questionnaire, meaning that all items on a certain scale can be removed. When it's obvious that a certain scale isn't relevant, it may make sense to condense the questionnaire (Schrepp et al., 2017b).

D. Conclusion

The research has been succeeding implement for measure six instruments represent three scale value. The answer for the question related to novelty has one inconsistency, but we can ignore it, since the three other questions have a highly consistent result and positive result. Based on the result in research analysis and discussion, it can be concluded that the usability test has positive response. Values between -0.8 and 0.8 indicate a neural evaluation of the corresponding scale, values > 0,8 indicate a positive evaluation, and values < -0,8 indicate a negative evaluation, according to the traditional interpretation of the scale and the result of six instruments below 2,5. The result according to 3 aspects: Attractiveness, hedonic and pragmatic quality. the results of benchmarking the airfield lighting system have a good value, with "excellent" scale attractiveness, perspicuity, efficiency, dependability, and stimulation. This result can be interpreted as the airfield lighting system already in the range of the 10% best result compared to a similar product. The result is "above average" reached by the novelty scale, which means the airfield lighting system is in the middle, with 25 % of the result in the data set better than the airfield lighting system but 50 % worse.

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