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IMUW-APP: An instrument for measuring the usability of web applications

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ABSTRACT

Conventional usability measurement methods for measuring web applications are costly, sometimes time-consuming, and may require professionals. The frameworks, methods, approaches, and tools in which web applications are designed can fully support these limitations. The main issue is to speed up the evaluation process of websites in an effortless manner. To overcome this limitation, this paper proposes an instrument that can use for measuring the usability of web applications (IMUW-APP). A systematic literature review was utilized to determine the instrument dimensions and their items. The validity and reliability test were conducted via face and content validity, goodness testing, and pilot study. Cronbach's Alpha, factor loading, Kaiser-Meyer-Olkin, and Barlett's test were +calculated to ensure the validity and reliability of the proposed instrument. In the light of our analyses, the obtained findings indicate that the proposed instrument (IMUWAPP) is workable and can adapt. Besides, a case study is used to verify the proposed instrument to evaluate a university website. The collecting data have been analyzed and visualized. Ultimately, the overall findings have highlighted.

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1. INTRODUCTION

The online presence has a positive impact on making more revenue [1], [2]. Therefore, the quality of the organization's website influences results. There is one way to distinguish between the work of a company and the work of other companies is to have a distinctive website following the standards adopted in building websites [3], [4]. The main issue is the measuring and evaluation of websites have to be speedy as possible.

Web applications have become complex in terms of how they work and how they use. Following functional requirements in website design gives more benefits to be gained using websites. To gain the benefits of the web application features, web developers have to follow the requirements and limitations of using this application [4]-[6]. Besides, human-computer interaction and usability engineering become essential in web application development. Overall, stakeholders prefer to have web applications with high usability as well as when there are many similar applications is exist [7], [8].

Usability defines as an evaluation process for a service or a product by experimenting with such a product with the selected users. In other words, the usability of a web application is application capability in terms of understanding, learning, and attractiveness to users. According to [9]-[11], usability is essential as a

utility, and combining them (usability+utility) will identify the usefulness of a software product. Referencing the definition in the previous section, usability has gained attention in web applications, since this study concerns with web-applications usability testing, the systematic literature review (SLR) used to identify the proposed instrument dimensions, consequently, the proposed instrument should test the web-application usability based on these dimensions.

In the rest of this paper, section 2 has focused on the research methodology used, section 3 highlighted the obtained result, section 4 has outlined the development side of the proposed instrument. Section 5 demonstrates an evaluation of the selected web application using the proposed instrument. Section 6 displays overall findings. While section 7 outlines the study conclusion.

2. RESEARCH METHOD

2.1. Articles selection and quality assessment

Three authors evaluated all the articles identified in this study independently. After reviewing the article's titles, abstracts, and full texts, the irrelevant articles have been discarded. The rest articles have investigated using the quality assessment checklists as supported by [12]-[15]. The implication standards in this study were the studies, which focus on measuring usability in the software engineering field.

2.2. The database search

The databases, including EBSCO, Science Direct, PubMed, Web of Science, Scopus, as well as Google Scholar. Besides, the articles searched are among 2005 to 2021 belong the usability in web applications as well as developing usability instruments as supported by [16]-[18].

3. RESULT

In total, 53 most relevant papers from 2005 to 2021 were included in the present systematic review. As mentioned earlier, a systematic literature review of the relevant studies has conducted to identify the instrument dimensions and items. SLR was select for the body of literature to aggregate, review, and assess based on developed SLR protocol. Besides, the process of performing SLR consists of several steps as shown in Figure 1. Based on the SLR finding, the proposed instrument to measure the usability of the web applications should have seven dimensions, which are visibility, learnability, simplicity, flexibility, decision-making support, usefulness, and error handling and tolerance. Besides, the SLR findings portray that each dimension of the proposed instrument has its items.

Figure 1. The SLR protocol

4. INSTRUMENT DEVELOPMENT

The development procedure of the proposed instrument starts with identifying the usability dimensions with associated items, followed by designing the first draft of the instrument. Subsequently, a pilot test was conducted which will be resulting in the final instrument. Figure 2 depicts the development approach of an instrument.

4.1. The first draft instrument

Based on the development approach, the first edition of the proposed instrument has been assembled and issued. As mentioned earlier, the proposed instrument has seven dimensions and each dimension has its items. Accordingly, the first draft instrument consists of seven dimensions and 69 items spread over these dimensions, some of the selected items have been adapted from existing studies while the authors proposed the rest. Table 1 lists the first draft of the proposed instrument. In line with the above situation, the proposed instrument consists of two main parts, the first one focuses on demographic data of the selected sample;

while the second part is, the 69 items used to measure the usability of a web application as shown in Table 1. Hence, a 9-point like rt-type scale starts with “very strongly disagree” ends with “very strongly agree” used in the study.

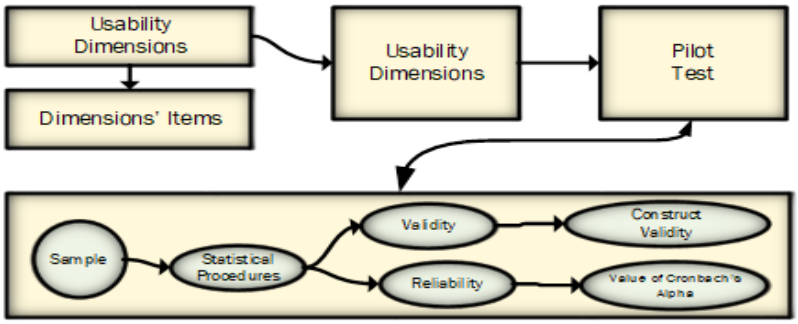

Figure 2. The development approach of instrument

Table 1. The first draft of the proposed instrument

Dimensions	Items	The Relevant References
Visibility	(8) Items	[19]-[25]
Learnability	(9) Items	[26]-[32]
Simplicity	(10) Items	[33]-[36]
Flexibility	(9) Items	[37]-[41]
Decision-Making Support	(10) Items	[42]-[49]
Usefulness	(8) Items	[50]-[57]
Error Handling and Tolerance	(9) Items	[58]-[61]
Total	69 Items	

4.2. Instrument goodness testing: pilot study

Reviewing relevant literature extensively indicates that conducting a pilot study can help to; i) measuring the instrument dimensions and their items and ii) to confirm the instrument is ready to use by actual users. Thus, the validity, consistency, tests, and their relevant findings have detailed in the following.

4.2.1. Validity

The initial version of the instrument needs to be validated by the validity and consistency, which is divided into two parts face validity and content validity. The main aim of the validity test is to check whether this instrument has the measurability of the purpose, for which it has been designed. Consequently, face validity measures the flow of the content while content validity measures the relevancy of the instrument elements. As a response to that, five experts were engaged to review the proposed instrument. Despite some expert comments, the majority of the proposed instrument's items are good. Thus, applying for the expert's review makes an essential adjustment. Overall validity test is based on relevancy and understanding. The obtained finding of the validity test is depicted in Figure 3. While Table 2 presents three demographics of experts that participated in this study review session. These numbers are sufficient for the expert review of this study, as supported by [62].

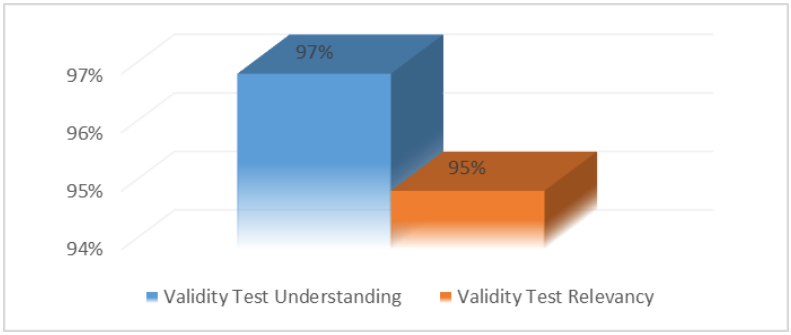

Figure 3. The validity findings

Table 2. Demographic profiles of experts

No. of Experts	Field of Expertise	Experience (Year)	Location
2	Academician	20	Iraq
2	Developer	15	Malaysia
1	Developer	16	Iraq

4.2.2. Measuring the reliability

Measuring reliability focuses on checking the instrument's items whether they are being fitted and complementary to each other. Each of the items has a numeric representation. This study was randomly selected 45 participants among web applications' actual users and developers. The collected data will be integrated into a statistical procedure, Cronbach's alpha statistics have been conducted, to obtain the evidence that the instrument has been validated. The reliability findings have shown in Table 3.

Table 3. Reliability test and findings

Dimensions	Sample Selected	CA	No. of Items
Visibility (V)	45	0.923	8
Learnability (L)	45	0.977	9
Simplicity (S)	45	0.942	10
Flexibility (F)	45	0.881	9
Decision-Making Support (DMS)	45	0.876	10
Usefulness (U)	45	0.915	8
Error Handling and Tolerance (EHT)	45	0.896	9

Note: CA means Cronbach's Alpha

4.2.3. Construct validity

According to [63], testing the validity of the instrument dimensions used a sample size greater than or equal to 100 participants to obtain the reliable essential outcome. The total number of participants used in this study is 153 respondents. Then validity was assured and the factor analysis is used for deciding items to deletes or used. The aim of identifying factor analysis is to verify the level of to what extend the significance of each instrument's item and suitability to each dimension [64]. Consequently, the test has run and directed to accept the relevant items by utilizing KMO (Kaiser-Meyer-Olkin) and Bartlett's test of sphericity, and Factor loading. The test should be based on the following rules. Consequently, the results have tabulated in Table 4 (see Appendix).

- KMO value ≥ of 0.50 is acceptable.
- Bartlett's value of $p \leq 0.05$ is acceptable.
- Factor loading value acceptable should be ±0.30 to ±0.40.

As is clearly evident from Table 5, the number of elements in the proposed instrument varies due to the effect of factor loading for all dimensions of the proposed instrument. For example, the visibility dimension has 8 items before applying factor loading, while it has 6 items after applying factor loading.

As indicated in Table 3, all the Instrument's items are confirmed valid and can be utilized except for items marked with (*) which illustrate loading values > 0.50. Consequently, the final draft of the proposed instrument not included the items marked with (*). Thus, the total number of items after the construct validity test is 40 items. To measure the extent to which the elements are related to their dimension, the factor loading technique was also utilized. The final draft of the proposed instrument is illustrated in Table 5.

Table 5. The proposed instrument (final draft)

Dimensions	Items Before Factor Loading	Items After Factor Loading
V	V-Item 1… V-Item 8	V-Item 1… V-Item 6
L	L-Item 1… L-Item 9	L-Item 1… L-Item 6
S	S-Item 1… S-Item 10	S-Item 1… S-Item 6
F	F-Item 1… F-Item 9	F-Item 1… F-Item 5
DMS	DMS-Item 1. DMS-Item 10	DMS-Item 1 DMS-Item 6
U	U-Item 1… U-Item 8	U-Item 1… U-Item 5
EHT	EHT-Item 1… EHT-Item 9	EHT-Item 1… EHT-Item 6

5. USE THE PROPOSED INSTRUMENT IN TEST WEB-APPLICATION

As mentioned earlier, checking usability is an essential part of web application development. Most organizations strive for their web applications to be easy to use as well as the other basic services. In the context of this study, a web application belong to a well-known educational Insitute was selected to test the usability using the proposed instrument.

The proposed instrument has randomly distributed to a sample that includes four categories from this intended institution (academics staff, administrative staff, students, and technical staff). Based on individual responses towards the usability of the intended website, 65% of the participants very strongly agree with the visibility of the intended website, while 10% of the participants strongly agree with the same dimension, and 6% of them are agreeing with it. The visibility findings have shown in Figure 4. Moreover, 50% of the participants very strongly agree with the learnability of the intended website, while 15% of the participants strongly agree with the same dimension, and 20% of them are agreeing with it. The learnability findings have shown in Figure 5.

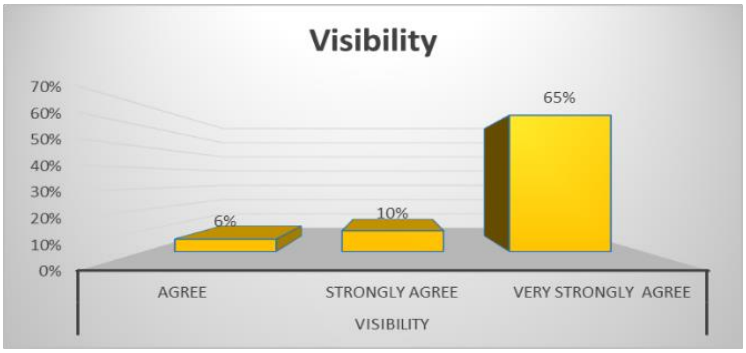

Figure 4. Visibility findings

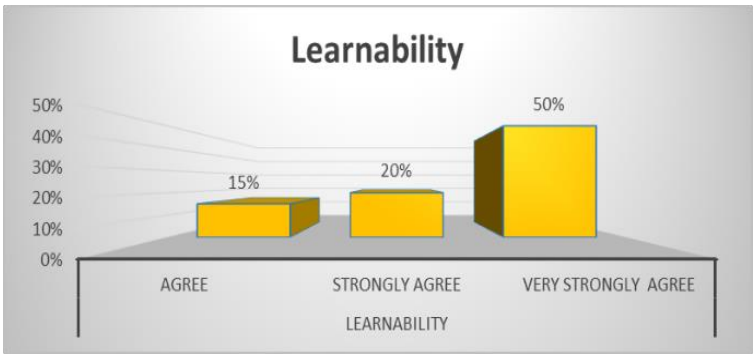

Figure 5. Learnability findings

Furthermore, 65% of the participants very strongly agree with the simplicity of the intended website, while 20% of the participants strongly agree with the same dimension, and 14% of them are agreeing with it. The simplicity findings have shown in Figure 6. In the same aspect, 78% of the participants very strongly agree with the flexibility of the intended website, while 9% of the participants strongly agree with the same dimension, and 10% of them are agreeing with it. The flexibility findings have shown in Figure 7. Besides, 80% of the participants very strongly agree with the decision-making support of the intended website, while 11% of the participants strongly agree with the same dimension, and 3% of them are agreeing with it. The decision-making support findings have shown in Figure 8.

Moreover, the majority (70%) of the participants very strongly agree with the usefulness of the intended website, while 11% of the participants strongly agree with the same dimension, and 10% of them are agreeing with it. The usefulness findings have shown in Figure 9. Ultimately, 65% of the participants very strongly agree with the error handling and tolerance of the intended website, while 15% of the participants strongly agree with the same dimension, and 10% of them are agreeing with it. The error handling and tolerance findings have shown in Figure 10.

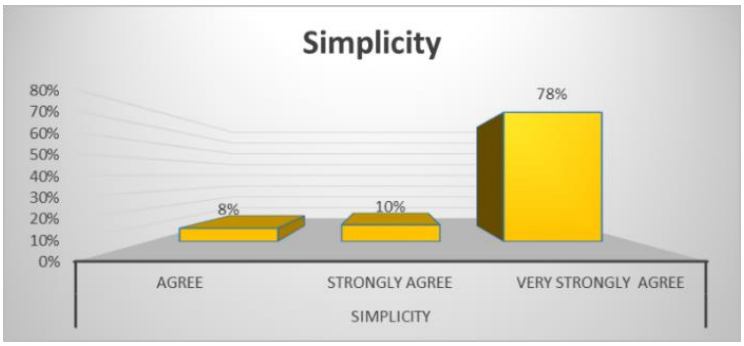

Figure 6. Simplicity findings

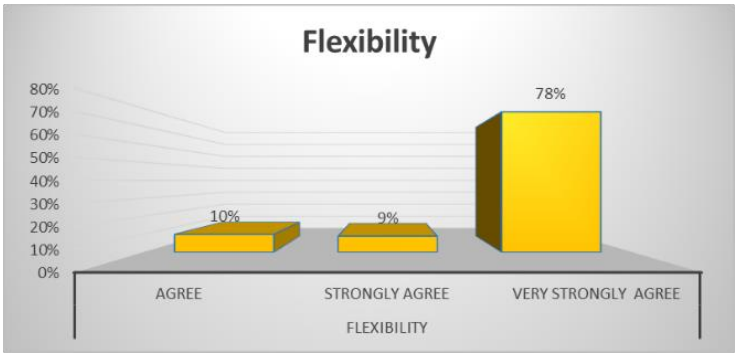

Figure 7. Flexibility findings

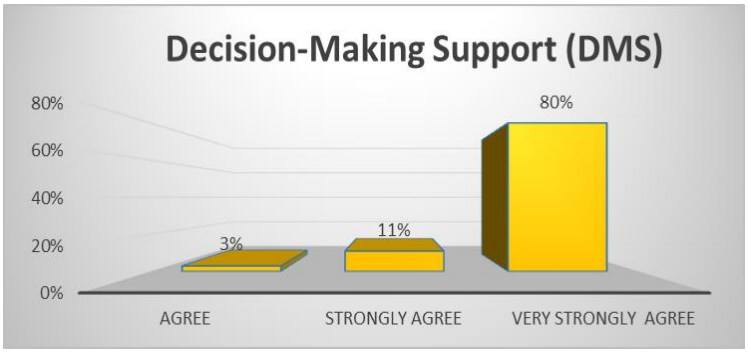

Figure 8. Decision-making findings

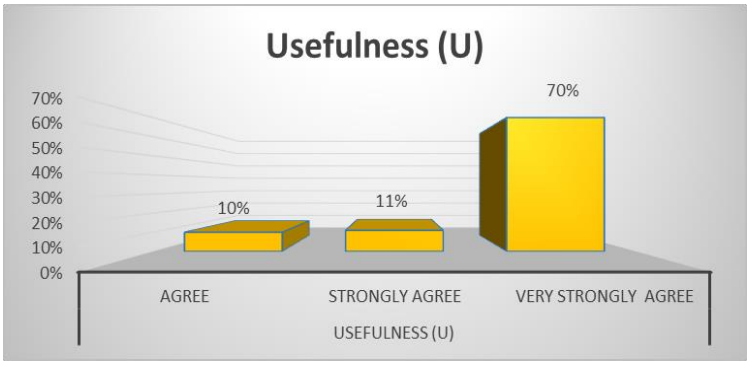

Figure 9. Usefulness findings

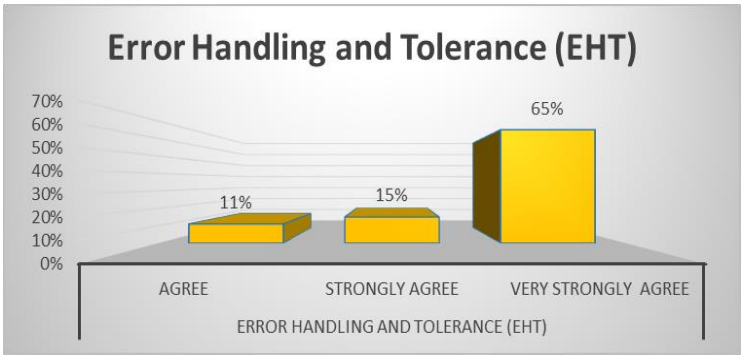

Figure 10. Error handling findings

6. OVERALL USABILITY TEST

As indicated in Figure 11, the findings showed that the selected website is usable. By summation up the percentage of the "very strongly agree, strongly agree, and agree" of each dimension of the proposed tool, the findings are: 91% for visibility, learnability was 85%, simplicity was 96%, flexibility was 97%, decision-making support was 94%, usefulness was 91%, and ultimately, error handling and tolerance was 91%. Consequently, the overall result indicates the intended website is usable. Figure 11 illustrated the overall usability test.

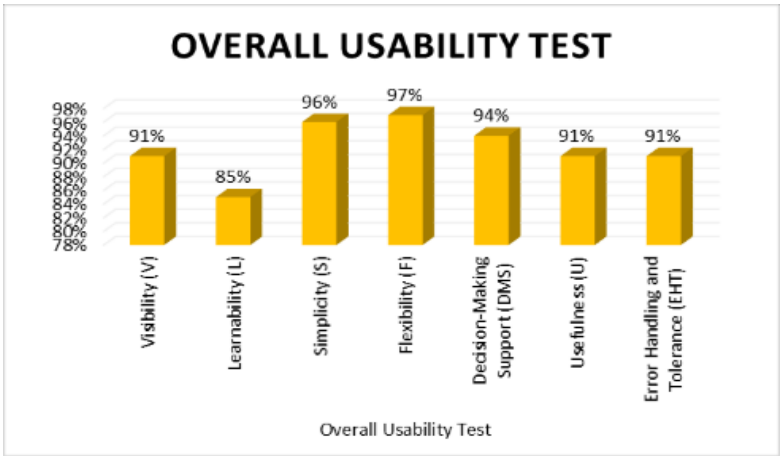

Figure 11. Overall usability test

7. CONCLUSION

The research has systematically identified the usability instrument and its dimensions as well as the relevant items to those dimensions. The main aim of the proposed instrument (IMUW-APP) is to help researchers and software companies to test the usability of their web applications. Seven dimensions were included in IMUW-APP: visibility, learnability, simplicity, flexibility, decision-making support, usefulness, and error handling and tolerance. Besides, a systematic literature review has been conducted to extract the IMUW-APP dimensions.

The validity test was conducted to test the relevance and understanding of the proposed instrument. Measuring the goodness of the proposed instrument was also conducted and the statistical procedure was calculated. The overall findings indicate the proposed instrument is workable in terms of web-application usability measuring as well as providing theoretical and practical guidelines for web developers to develop a workable usability-testing instrument. An educational official website was used as a case study to measure usability. The findings of the usability test were highlighted. The finding obtained shown that the proposed instrument is workable in practice in measuring the usability in a web application. Besides, the step by step that is used in developing such an instrument as well as can be productive for other researchers in this field either to adopt it or use it as a guideline to develop their own instruments.

APPENDIX

Table 4. Overall finding of dimensions validity

Dimensions	Items	KMO	Bartlett's Test	Factor Loading
Visibility (V)	V-Item 1	0.644	0.000	0.593
	V-Item 2	0.637	0.000	0.631
	V-Item 3	0.626	0.000	0.614
	V-Item 4	0.611	0.000	0.593
	V-Item 5	0.697	0.000	0.641
	V-Item 6	0.695	0.000	0.684
	V-Item 7	0.648	0.000	0.323*
	V-Item 8	0.613	0.000	0.421*
Learnability (L)	L-Item 1	0.647	0.000	0.523
	L-Item 2	0.643	0.000	0.681
	L-Item 3	0.619	0.000	0.674
	L-Item 4	0.621	0.000	0.373*
	L-Item 5	0.635	0.000	0.651
	L-Item 6	0.648	0.000	0.414*
	L-Item 7	0.646	0.000	0.513
	L-Item 8	0.643	0.000	0.333*
	L-Item 9	0.648	0.000	0.682
Simplicity (S)	S-Item 1	0.629	0.000	0.393*
	S-Item 2	0.693	0.000	0.633
	S-Item 3	0.619	0.000	0.481*
	S-Item 4	0.628	0.000	0.597
	S-Item 5	0.637	0.000	0.336 *
	S-Item 6	0.646	0.000	0.692
	S-Item 7	0.637	0.000	0.543
	S-Item 8	0.648	0.000	0.688
	S-Item 9	0.649	0.000	0.547
	S-Item 10	0.641	0.000	0.399*
Flexibility (F)	F-Item 1	0.643	0.000	0.382*
	F-Item 2	0.649	0.000	0.681
	F-Item 3	0.644	0.000	0.342*
	F-Item 4	0.648	0.000	0.555
	F-Item 5	0.645	0.000	0.631
	F-Item 6	0.649	0.000	0.442*
	F-Item 7	0.641	0.000	0.387*
	F-Item 8	0.642	0.000	0.635
	F-Item 9	0.645	0.000	0.671
Decision-Making Support (DMS)	DMS-Item 1	0.612	0.000	0.577
	DMS-Item 2	0.624	0.000	0.391*
	DMS-Item 3	0.634	0.000	0.645
	DMS-Item 4	0.653	0.000	0.393*
	DMS-Item 5	0.673	0.000	0.421*
	DMS-Item 6	0.686	0.000	0.434*
	DMS-Item 7	0.677	0.000	0.513
	DMS-Item 8	0.689	0.000	0.611
	DMS-Item 9	0.608	0.000	0.634
	DMS-Item 10	0.617	0.000	0.594
Usefulness (U)	U-Item 1	0.671	0.000	0.593
	U-Item 2	0.641	0.000	0.312*
	U-Item 3	0.647	0.000	0.492*
	U-Item 4	0.643	0.000	0.375*
	U-Item 5	0.648	0.000	0.631
	U-Item 6	0.649	0.000	0.699
	U-Item 7	0.643	0.000	0.572
	U-Item 8	0.648	0.000	0.644
Error Handling and Tolerance (EHT)	EHT-Item 1	0.647	0.000	0.572
	EHT-Item 2	0.643	0.000	0.691
	EHT-Item 3	0.621	0.000	0.662
	EHT-Item 4	0.654	0.000	0.599
	EHT-Item 5	0.684	0.000	0.638
	EHT-Item 6	0.649	0.000	0.661
	EHT-Item 7	0.634	0.000	0.488*
	EHT-Item 8	0.649	0.000	0.331*
	EHT-Item 9	0.621	0.000	0.442*

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