The analysis of exploratory factors on the development of data, technology, and human literacy assessment instrument

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Abstract. This study focused on constructing data providers, technology, and human factors based on the interaction of items using factor analysis. The research instruments developed using the 4-D model are defined, design, develop, and disseminate. The research subjects were 115 students of the tenth grade of SMK Texmaco Semarang. The instruments that were tested were instruments form; they are multiple-choice and non-test instruments, they are observation sheets and scales. Data analysis was carried out through a construct validity test using factor analysis. Based on the results of the construct validity, it was found that all indicators in the test and non-test instruments were effectively involved in measuring data, technology, and human literacy. This result is shown from the effective proportion of each literacy indicator which reaches more than 30%. The results of the analysis factors showed that the test instrument contains literacy, technology, and human data according to the provisions of Education 4.0. The results on the non-test instrument found that human literacy skills can be assessed through openness, communication, collaboration and innovation, technological literacy skills through concepts and technology development.

1. Introduction
The industrial revolution 4.0 has changed the paradigm of implementing education 4.0 so that it is mutually supportive and sustainable. In the industrial revolution 4.0, equipment, machines, sensors, and humans were designed to be able to communicate with each other using the internet or call the Internet of Things (IoT) [1]. Thus the implementation of education 4.0 must also optimize the use of technology to increase connectivity between artificial and virtual intelligence with the development of digital systems. One way to achieve this is to switch from old literacy (reading, writing, arithmetic) to new literacy (data, technology, human) [2].

Data literacy includes reading, processing, and analyzing information (experimental data) from the digital world. Technology literacy includes understanding and implementing digital technology applications in learning. Aspects of human literacy skills consist of communication and design skills. In learning the industrial revolution 4.0, digital literacy skills are clarified and emphasized by the terms data literacy, technological literacy, and human literacy.

Digital literacy is related to skills in utilizing ICT [3]; operating technology and critical thinking [4]; conduct information searches using software [5]; as well as a study of the working principle of the tool...
The digital literacy component is very broad and includes all processes of technology utilization. This component is beneficial for students to get success in real life in the future [7].

Communication indicators on human literacy are related to expressing opinions, discussing, asking, and understanding problems in life [8] [9] [10], as well as the use of appropriate language structures [11]. These skills are influenced by a sense of caring and mutual support [12], openness, respect, and mutual trust [13], and motivation from within [14]. Students who actively communicate feel more courageous and confident when asking questions or having opinions in the class [15] and are more active in collaborating with their group friends [16] [17].

The educational challenge in the era of the industrial revolution 4.0 is in the form of changes in the way of learning, thinking patterns, and the way students act in developing creative innovations in various fields. To answer these challenges, an assessment of aspects of data literacy, technology, and humans in learning is needed [18]. Thus, the development of an assessment instrument can be used as an alternative in obtaining the information needed to understand the aspects that become the assessment standards in achieving these literacy skills.

Instrument development analysis can be done through factor analysis. Factor analysis is a statistical analysis tool used to reduce the factors that affect a variable to only a few sets of indicators without losing significant information. This analysis provides tools to analyze the structure of the internal relationship or correlation among a large number of variables by explaining the good correlation between variables, which is assumed to represent the dimensions in the data [19].

This research was conducted to examine the construction of factors that make up the data literacy assessment instrument, technology, and human-based on the results of factor analysis. The focus of this research study is to interpret the literacy items involved in the assessment instrument. This is done to provide an overview of the extent to which literacy indicators are involved in the assessment instrument.

2. Methods
This research is part of research and development or Research and Development (R & D). The model used is 4-D which includes defining, designing, developing, and disseminating. This research was preceded by the analysis of the needs assessment stage in physics learning at SMK Texmaco Semarang. Then with the design of the instrument, namely the analysis of indicators for each aspect of data literacy, technology, and humans. Furthermore, conducting instrument assessments including limited scale testing and wide-scale trials. The last stage is the dissemination that has been carried out through the publication of research results at the limited-scale trial stage in national journals.

The results of the limited-scale trial were analyzed through Aiken's validity, reliability, and item characteristics. The limited scale trial involved 36 students and was still limited to the test instrument. A wide-scale trial was carried out for the research subjects as many as 115 students. The data analysis was more complex, namely for the test and non-test instruments. The analysis includes constructing validity, reliability, instrument item characteristics, and student literacy profiles. The validity of the construct is used to determine the construction of the factors that make up the developed assessment instrument. Each item on the instrument is checked for composition whether it can measure the desired aspect.

The factor analysis carried out is an exploratory type in which the formed factors are used to interpret literacy items. Factor analysis is performed using IBM Statistic 22 software. The steps are as follows: 1) Click Analyze, 2) Select Dimension reduction, 3) Click Factor, 4) Enter instrument items into the variable column, 5) Click Descriptive and tick KMO and Bartlet's test of sphericity, 6) Select Continue, 7) Click Extraction and check the scree plot and continue, 8) Click Rotation, 9) Select Varimax, 10) Click options and check sorted size by and suppress small coefficient, 11) Fill in the value 0, 3 for absolute value below, 12) Click OK. Then proceed to analyze the results of factor analysis [20].
3. Results and Discussion

The results of the exploratory factor analysis are used to determine the factors that make up the assessment instrument. This analysis was carried out on test and non-test instruments. The test instrument has 9 literacy indicators, while the non-test instrument has 14 indicators. The developed test instrument was multiple-choice questions, and the non-test instrument consisted of an observation sheet and a scale. The results of factor analysis using IBM Statistic 22 software include KMO and Bartlett's test, the percentage of effective contributions, the percentage of factor variance, and the value of the loading factor.

3.1 KMO and Bartlett's Test

The Kaiser-Meyer-Olkin (KMO) value is a determining indicator that the research sample has met the minimum number for factor analysis. It is different from the value of Bartlett's Test of Sphericity which shows whether or not there is a correlation between variables as a first step in factor analysis. The results of KMO and Bartlett's test scores for the instruments have been clearly shown in Table 1.

Table 1. KMO and Bartlett's Test Results on the Instruments

|                          | Tes  | Non-Test |
|--------------------------|------|----------|
|                          | Literasi Teknologi | Literasi Manusia |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | 0.751 | 0.788 | 0.810 |
| Bartlett's Test of Sphericity | Approx. Chi-Square: 160.317 | 193.171 | 824.963 |
|                          | df: 36 | 21 | 136 |
|                          | Sig.: 0.000 | 0.000 | 0.000 |

Table 1 shows that the KMO value for the test and non-test instruments have been greater than the specified value, namely 0.5. Bartlett's Test of Sphericity value for the two types of instruments has also shown a correlation between variables because of the sig. <0.05. Thus the number of samples has been declared sufficient to perform factor analysis and can be used to determine the correlation between variables [20]. The results of the factor analysis on the non-test instrument were carried out separately between technological and human literacy. This is because the indicators for each aspect of literacy are quite numerous, so that they cannot be done simultaneously.

3.2 Factor Variants

The percentage of construct variance in the test instrument can be explained by several factors formed in the Total Variance Explained table. The factor variant shows the number of factors formed based on the Eigenvalue. The results of the construct variants are shown by the eigenvalues in Table 2.

Table 2. Results of Factor Variants

| Component | Test Instrument | Instrumen Non-Test |
|-----------|-----------------|--------------------|
|           | Eigen | Variant (%) | Eigen | Variant (%) | Eigen | Variant (%) |
| 1         | 2.755 | 30.611 | 2.83 | 40.45 | 6.04 | 35.55 |
| 2         | 1.369 | 45.823 | 1.30 | 59.09 | 1.85 | 46.42 |
| 3         | 1.020 | 57.161 | -    | -    | 1.45 | 54.95 |
| 4         | -     | -       | -    | -    | 1.12 | 61.54 |
The determination of the factors in the test and non-test instruments is obtained through the eigenvalues in Table 2. The total eigenvalues of more than 1 are factors, while the eigenvalues less than 1 are not factors and will not be included in the discussion. Based on Table 2, it is found that 3 factors can explain the variance on the test instrument and 2 factors for the non-test instrument on the technological literacy aspect, and 4 factors for the human literacy aspect. The variance values show the cumulative proportion of the eigenvalues interaction in the instrument.

Analysis of the proportion of the test instrument found that factor 1 can explain 30.611% of the variance, factor 2 can explain 45.823% of the variance, while factor 3 can explain 57.161% of the variance. The technological literacy aspect of non-test instruments has cumulative variance values of factors 1 and 2, namely 40.45% and 59.09. Another case in human literacy is formed by 4 factors with the proportion of cumulative variants, respectively 35.55%, 46.42%, 54.95%, and 61.54%.

3.3 Loading Factor
The factors in the test instrument can be shown through the results of the factor loading value to interpret the factors. The result of factor loading in SPSS is shown in the Rotated Component Matrix table. The value of the factor loading (load factor) on the test instrument can be seen in Table 3.

Table 3. Results of the Load Factor on Test Instruments

| Indicator                          | Factor 1 | Factor 2 | Factor 3 |
|-----------------------------------|----------|----------|----------|
| Creating a conclusion             | 0.720    |          |          |
| Evaluating technology             | 0.694    |          |          |
| Interpreting data                 | 0.531    |          |          |
| Organizing data                   | 0.526    |          |          |
| Applying the concept in technology| 0.749    |          |          |
| Determining formula               | 0.701    |          |          |
| Combining concept                 | 0.534    |          |          |
| Planning concept                  |          | 0.809    |          |
| Rearrange concept                 |          | 0.727    |          |

Table 3 shows that factor 1 includes 4 question indicators, factor 2 consists of 3 question indicators, while factor 3 is formed from 2 question indicators. The factor interpretation is considered significant if the factor loading value is 0.5 or more. Question indicators that have a factor load value below 0.5 can be considered for abortion or revision. The overall factor load results have a value above 0.5 so that all of them can be used to assess the factors in the test instrument.

The most important factor analysis is shown through the value of the factor loading. The results of the factor load are used to determine the correlation of all indicators measured in each aspect of the technological literacy and human literacy instruments. The value of the factor loading on the non-test instrument is divided into two, namely the aspects of human literacy and technological literacy. The results of the factor load on the aspect of human literacy can be seen in Table 4.
Table 4. Results of the Load Factor on Human Literacy

| Indicators                                   | Factors |
|----------------------------------------------|---------|
|                                              | 1  | 2   | 3   | 4   |
| Positive thinking                            | 0,75 |     |     |     |
| Appreciating opinion                         | 0,69 |     |     |     |
| Showing concern                              | 0,67 |     |     |     |
| Understanding opinion                        | 0,67 |     |     |     |
| Not being selfish in discussing              | 0,59 |     |     |     |
| Expressing opinion                           | 0,59 |     |     |     |
| Deciding the strategy                        | 0,56 |     |     |     |
| Giving opinion                               | 0,76 |     |     |     |
| Giving appreciation                          | 0,67 |     |     |     |
| Being fair                                   | 0,64 |     |     |     |
| Giving support                               | 0,46 |     |     |     |
| Looking for references                       | 0,45 |     |     |     |
| Developing the idea                          | 0,28 |     |     |     |
| Start discussing                             | 0,70 |     |     |     |
| Planning design                              | 0,66 |     |     |     |
| Making design                                | 0,93 |     |     |     |
| Presenting the result                        | 0,93 |     |     |     |

Table 4 provides information that factor 1 has 7 indicators, factor 2 has 6 indicators, factor 3 has 2 indicators, and factor 4 also 2 indicators. Overall, the value of the factor load is quite high, except for the indicators of developing ideas. In this indicator, the factor load value is very small, namely 0.28, so that it can be a consideration for revision or disposal. These results indicate a factor component in the aspect of human literacy skills. Statement indicators in this aspect contain communication components (skills and factors that influence it) and design. Some of the factors that influence communication skills are viewed from students' attitudes in interacting.

Aspects of human literacy are related to humanities, communication, and design. Based on the 4 factors that have been formed, it is found that factor 1 represents openness in communicating during discussions, factor 2 represents mutual support when working together, factor 3 is related to innovation, and factor 4 represents a wide range of oral communication. Thus it can be said that the factors that can be used to shape human literacy skills in this study are aspects of openness, communication, collaboration, and innovation. This factor is part of 21st-century skills, namely communication and collaboration. The competencies needed in the 21st century are communication, collaboration, critical, and creative [21]. Furthermore, the value of the factor load on the aspect of technological literacy is presented in Table 5.
Table 5. Results of the Load Factor on Technology Literacy

| Indicators                          | Factors |
|------------------------------------|---------|
|                                    | 1       | 2       |
| Formulating physical equation      | 0.77    |         |
| Actively participate               | 0.77    |         |
| Linking concepts                   | 0.76    |         |
| Giving argumentation               | 0.75    |         |
| Using a computer device            | 0.57    |         |
| Comparing understanding            |         | 0.63    |
| Modifying concepts                 |         | 0.59    |

Based on Table 5, we know that the 7 statement indicators have formed 2 factors. Factor 1 includes 5 indicators, and factor 2 has 2 indicators. Factor 1 consists of formulating equations, active participation, linking concepts, providing arguments, and using ICT tools. Factor 2 includes comparing understanding and modifying concepts. The interpretation of the factor load results shows that factor 1 is related to the integration of concepts and technology, while factor 2 is related to technology development.

The results of these technological literacy skills are also supported by the results of the assessment of data, technology, and human literacy skills in the cognitive aspects. The ability of science (physics) and technology is closely related because if the application of science in technology is low, it shows that scientific knowledge is also low [22] [23]. The development of technological literacy aspects in education 4.0 can be done by presenting mobile devices in the classroom and presenting virtual laboratories that can be accessed easily [24]. Mobile technology has changed what students learn in knowledge content as well as changing the way students learn [25].

4. Conclusion

The construction factors of the test instruments are data literacy, technology, and human. In the non-test instrument, human literacy skills can be measured through openness, communication, collaboration, and innovation, while technology literacy skills are through the application of concepts and technology development. These results were obtained from construct validity through factor analysis. Factor analysis shows that all indicators in the test and non-test instruments have been effectively involved in measuring data, technology, and human literacy. This result is shown from the percentage of effective contribution of each literacy indicator which reaches more than 30%.

For another researcher, the writer suggests them to carry out further studies on the relationship between data literacy, technology, and humans by using confirmatory or regression factor analysis. Besides, data, technology, and human literacy assessment instruments can be developed for other materials or in the other question forms, which are descriptions by considering the results of the factor analysis in this study. The application of this assessment instrument can also be carried out in other schools which have similar problem analysis with SMK Texmaco Semarang.

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