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Static Fluid Four-Tier Instrument (SFFTI): Develop and Identify K-11 Brebes-Scholars' Alternative Conception with Rasch Analysis

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Abstract

The aim of this research was to Develop and Identify K-11 Brebes-Scholars' Alternative Conception with Rasch Analysis. The research method used a 4D model (Defining, Designing, Developing, and Disseminating). The instrument developed has been tested to 36 Scholars (10 tole (call for boys) and 26 mbae (call for girls), whose ages were average of 16 years-old) in one of school in Brebes. The data was examined using Rasch analysis on validity, reliability, and level of difficulty. The resulting research showed that the Static Fluid Four-Tier Instrument (SFFTI) diagnostic test is able to identify scholars' alternative concepts of static fluid concepts.
Keywords: *Static Fluid Four-Tier Instrument (SFFTI), Alternative Conception, Brebes-Scholar, Rasch Analysis*

1. Introduction

Static Fluid Four-Tier Instrument (SFFTI) is the development of diagnostic tests to identify alternative concept owned by scholars. This is important because understanding the concept that scholars have is sometimes wrong. Conceptual understanding is an image of education results. This is because each scholars comes to class with their respective concepts based on their experiences [1], [2], 3]. The initial concept of a scholars is built based on his thoughts, so the concept is not necessarily true. The initial concept of scholars who are not in accordance with scientific concepts agreed upon by scientists is called misconception [4], [5], [6]. Other, terms that are often used with the same intentions as misconceptions include alternative concepts, preconceptions, naive conceptions, alternative frameworks [7].

In general, alternative conceptions have the characteristic of being strongly held with high confidence [1]. Thus, alternative conceptions are difficult to overcome [8]. If left unchecked, alternative conceptions will continue to be attached to scholars for a long period of time [9], [10], [11]. [12] Explains that the importance of identifying alternative conceptions in scholars due to wrong concepts or alternative conceptions will cause scholars to experience errors at the next level or the inability to connect between concepts. Therefore, there must be an anticipation of alternative conceptions that occur in scholars.

Alternative conceptions cannot be known directly but must use diagnostic tests [13]. The diagnostic test instrument is a test to measure the conception and identify alternative conceptions of scholars [8]. There are several diagnostic tests to identify scholars' alternative conceptions, namely interviews, open-ended tests, multiple-choice tests, and multi-tier multiple-choice tests (two-tier, three-tier, and four-tier) [1] have advantages and disadvantages of each, but based on a literature review, a multiple-choice test in the form of a four-tier format is effectively used to diagnose scholars' alternative conceptions [10].

Four-tier is the development of a three-tier test [5]. The development contained in the increased tier of scholars' confidence in choosing answers and reasons. The first tier is a multiple-choice question with four deceptions and one answer key that scholars must choose. The second tier is the level of scholars' confidence in choosing answers. The third tier is the

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reason scholars answer questions. In the form of closed reasons. The fourth tier is the level of scholars' confidence in giving reasons [1].

Alternative conceptions are often found in the field of physics, one of which is about fluids [14], [15], 16]. Scholars still experience many alternative conceptions of the material. According to research conducted [17], showed were still many scholars have misconceptions with 70.8% In Pascal law, 67.6% in Archimedes law and 55.7% in hydrostatic pressure. This is supported by research [25], [18], which states that there are some conceptual difficulties that scholars have, namely the use of the floating force formula, the determination of all forces acting on the plane in fluid, the force produced in the plane in fluid, and the determination of depth of field in fluid. Based on this, we developed a four-tier format diagnostic test on the static fluid concept with the aim to identify Brebes-Scholars' alternative conceptions with SFFTI diagnostic test. The results of the research data will then be analyzed with Rasch.

The Rasch model introduced by Georg Rasch in the 1960s was the most popular IRT (item response theory) model [19]. One example of this application from Rasch is for the development of instruments. Several studies that have used Rasch's analysis in developing [2]multi-tiered format instruments (Two-Tier, Three-Tier, Four-tier) include, “Developing MeMoRI on Newton’s Laws: For Identifying Students’ Mental Models” [7], “Rasch Analysis of Multitier Open-ended Light-Wave Instrument (MOLWI): Developing and Assessing Second-Years Sundanese-Scholars Alternative Conceptions” [12], “The Three-tier Diagnostic Instrument: Using Rasch Analysis to Develop and Assess K-10 Students' Alternative Conceptions on Force Concept” [20], “Multilevel Rasch modeling of two-tier multiple choice test: A case study using Lawson’s classroom test of scientific reasoning” [21]. Thus, we hope that our research objectives can be optimally analyzed using Rasch analysis.

2. Methodology

2.1. Research Subject

The subjects in this research were 36 K-11scholars in one of the schools in Brebes. Brebes is a district in Central Java Province [22], which is 187 km from Semarang (the capital of Central Java Province) as shown in Figure 1. Social and cultural diversity in Indonesia makes each city or region have different characteristics. So, in this study we took scholarships from Brebes to identify alternative conceptions they had in the concept of static fluid. The scholar consisted of 10 *tole* (call for boys in Brebes), and 26 *mbae* (call for girls in Brebes) with an average age of 16 years old. The subject of this research has been studying static fluid concept.

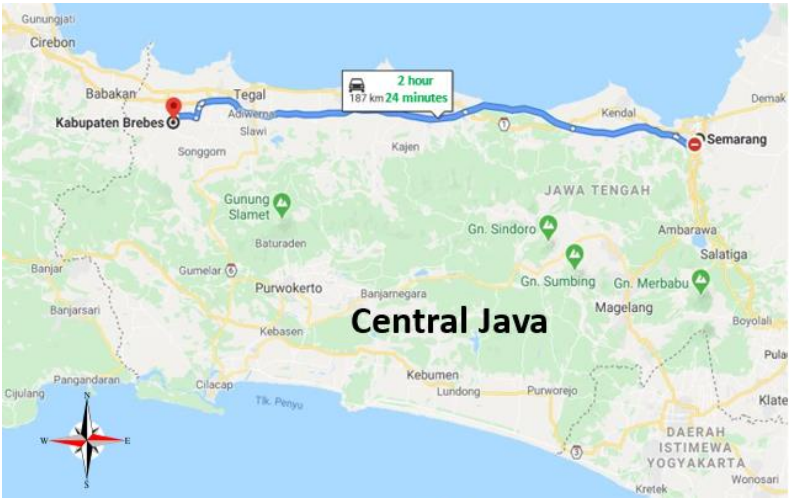

Figure 1. The Map of Brebes from Semarang (Source by: Google Maps)

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2.2. Research design

The design used in this study is the 4D model (Defining, Designing, Developing, and Disseminating). In the defining and designing phase, we investigate the two-tier and four-tier tests and design two-tier and four-tier test instruments. In the developing phase, we develop diagnostic tests from the two-tier test format to the four-tier test. The disseminating phase is the result of the SFFTI trial to identify alternative conceptions of Brebes-Scholars.

2.3. Data analysis

Data analysis consists of validation, reliability, and identification of alternative conceptions. The validation test is done by Rasch analysis using MINISTEP software based on item dimensionality by looking at the value of raw variance explained by measures. The reliability test in this study was analyzed by Rasch analysis using MINISTEP software based on item reliability. Meanwhile, to identify scholars' alternative conceptions seen from the pattern of scholars' answers. Each scholar's answer will be determined based on the answers given at each tier. The scholars' conception level is categorized based on five scholars' conception criteria adapted from [14] namely Understanding (U), namely the state of scholars who have a correct and complete understanding of the concept, Partial Understanding (PU), namely the state of scholars who only have a partial understanding of concepts and cannot explain a whole phenomenon, No Understanding (NU), namely the condition of scholars who do not understand the concept, Alternative Concepts (AC), namely the condition of scholars who have a conception that is not in line with scientific concepts, Un-Coded (UC), which is a condition if there is a tier that is not answered. The processing is in the form of coding based on a combination of scholar answer tables in Table 1.

Table 1. Combination of Four-Tier Test Answers

Conception Criteria	Tier			
	1	2	3	4
U	C	S	C	S
PU	C	S	C	NS
	C	NS	C	S
	C	NS	C	NS
	C	S	F	S
	C	S	F	NS
	C	NS	F	S
	C	NS	F	NS
	F	S	C	S
	F	S	C	NS
	F	NS	C	S
	F	NS	C	NS
NU	F	S	F	NS
	F	NS	F	S
	F	NS	F	NS
AC	F	S	F	S
UC	If not filling one or more items (tier)			

Note: U= Understand, PU= Partial Understanding, NU= Not Understanding, AC= Alternative Concepts, UC= Un-Coded, C= Correct; F= False; S= Sure; NS= No Sure

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3. Results and Discussion

3.1. Defining

The diagnostic test instrument is a test to measure the conception and identify alternative conceptions of scholars [8]. In this research, we developed a four-tier format diagnostic test from the two-tier format. Two-tier and four-tier tests are one form of diagnostic test. The two-tier test is a diagnostic test instrument with first tier multiple choice content questions and second tier choice reasons for first tier answers.

The four-tier test is the development of a three-tier test [20]. The development contained in the increased tier of scholars' confidence in choosing answers and reasons. Tier 1 is a multiple-choice question with four deceptions and one answer key that scholars must choose. Tier 2 is the level of scholars' confidence in choosing answers. Tier 3 is the reason scholars answer questions. In the form of closed reasons. Tier 4 is the level of scholars' confidence in giving reasons [1]. At tier 1 and 3 use sure and not sure to describe the level of confidence.

3.2. Designing

At this stage, it begins by determining the indicator indicators about static fluid material in accordance with the applicable curriculum as a guideline for making questions. Based on this grid, 14 items were generated in the form of an open multiple-choice or two-tier open-ended test. Following is the design of a two-tier open-ended test in Figure 2.

Question
Option Answer (Tier I) a. b. c. d. e.
Reason (Tier II) .....

Figure 2. Two-tier open-ended test design

Each question consists of multiple-choice questions at tier 1 and open reasons at tier 2. At tier 2 multiple choices are not used but open questions are asked thus, scholars can fill in the reasons based on their thinking. Then, the reason at tier 2 is used as a reference to transform into a four-tier format. The two-tier open-ended test has been transformed into a four-tier SFFTI format with the following design in Figure 3.

Question
Option Answer (Tier I) a. b. c. d. e.
Confidence (Tier II) a. Sure b. Not Sure
Option Answer (Tier III) a. b. c. d. e. .....
Confidence (Tier IV) c. Sure a. Not Sure

Figure 3. Static Fluid Four-Tier Instrument (SFFTI) design

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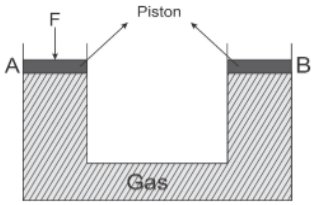
The SFFTI consists of four-tier, with tier 1 being a multiple-choice problem with four distractors and one answer key that scholars must choose. Tier 2 is the level of scholars' confidence in choosing answers. Tier 3 is the reason scholars answer questions. Tier 4 is the level of scholars' confidence in choosing reasons. At tier 3 an empty space is provided which scholars can fill if they feel there is no right answer.

3.3. Developing

At this stage a transformation is made from the two-tier format to the four-tier format. The two-tier instrument provided consisted of 14 items. The following example problem number 8 with the two-tier format is shown in Figure 4.

8.1. Sebuah bejana berhubungan dengan sistem tertutup memiliki luas penampang piston yang sama besar. Di dalam bejana tersebut diisi oleh suatu gas seperti pada Gambar 8.



Gambar 8

Jika piston A diberi gaya F, apa yang akan terjadi pada piston B?

a. Piston B mendapatkan gaya lebih besar dari gaya yang diberikan pada penampang A
b. Piston B mendapatkan gaya lebih kecil dari gaya yang diberikan pada penampang A
c. Piston B mendapatkan gaya sama besar dengan gaya yang diberikan pada penampang A
d. Piston B tidak terjadi perubahan kedudukan
e. Piston A mengalami tekanan dan tidak meneruskannya ke penampang B

8.2.Alasan kamu dalam menjawab pertanyaan 8.1 adalah.....
.....
.....
.....

Figure 4. Two-tier instrument

After the two-tier open-ended test instrument was given, the researcher then collected alternative answers on reason at tier 2 that identified alternative conceptions. After that the transformation of the two-tier test into a Static Fluid Four-Tier Instrument (SFFTI) diagnostic test is carried out. The transformation process is carried out by placing two or three reasons with the highest frequency and identifying alternative conceptions in the choice of answers or third tier options. This chosen reason is combined with some literature on alternative conceptions of static fluid material. Examples of Static Fluid Four-Tier Instrument (SFFTI) diagnostic test questions are shown in Figure 5.

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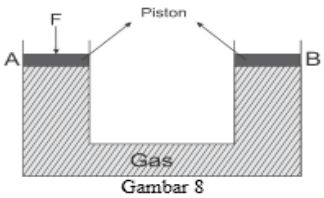
Sebuah bejana berhubungan dengan sistem tertutup memiliki luas penampang piston yang sama besar. Di dalam bejana tersebut diisi oleh suatu gas seperti pada Gambar 8.



Gambar 8

Jika piston A diberi gaya F, apa yang akan terjadi pada piston B …

a. piston B mendapatkan gaya sama besar dengan gaya yang diberikan pada penampang A
b. piston B mendapatkan gaya lebih besar dari gaya yang diberikan pada penampang A.
c. piston B mendapatkan gaya lebih kecil dari gaya yang diberikan pada penampang A.
d. piston A mengalami tekanan dan tidak meneruskannya ke penampang B.
e. piston B tidak terjadi perubahan kedudukan.

Apakah anda yakin dengan jawaban yang anda pilih?
a. Yakin b. Tidak yakin

Alasan anda memilih jawaban pada soal 8.1 adalah . . .

a. jika luas penampang sama, maka gaya yang diberikan pada salah satu penampang akan diterima lebih kecil pada penampang yang lainnya.
b. jika luas penampang sama besar, maka gaya yang diberikan pada salah satu penampang akan tertahan oleh gas di penampang tersebut.
c. tekanan akan diteruskan oleh fluida ke piston B lebih besar karena ada gas di dalamnya.
d. tekanan akan diteruskan oleh fluida sama besar ke segala arah.
e. lainnya: ……

Apakah anda yakin dengan alasan yang anda pilih?
a. Yakin b. Tidak yakin

Figure 5. Static Fluid Four-Tier Instrument (SFFTI)

3.4. Disseminating

At this stage, before identifying scholars' alternative conceptions, the SFFT diagnostic test was analyzed using Rasch analysis for validity, reliability and difficulty levels. Validity test using Rasch analysis can be seen in Figure 6.

```
INPUT: 36 Person  14 Item  REPORTED: 36 Person  14 Item  4 CATS  WINSTEPS 4.4.5
-------------------------------------------------------------------------------

     Table of STANDARDIZED RESIDUAL variance in Eigenvalue units = Item information units
                                       Eigenvalue   Observed   Expected
Total raw variance in observations     =      22.8420 100.0%          100.0%
  Raw variance explained by measures   =       8.8420  38.7%           37.4%
    Raw variance explained by persons  =       2.5896  11.3%           10.9%
    Raw variance explained by items    =       6.2524  27.4%           26.4%
  Raw unexplained variance (total)     =      14.0000  61.3% 100.0%    62.6%
    Unexplned variance in 1st contrast =       2.8283  12.4%  20.2%
    Unexplned variance in 2nd contrast =       1.8833   8.2%  13.5%
    Unexplned variance in 3rd contrast =       1.6323   7.1%  11.7%
    Unexplned variance in 4th contrast =       1.4972   6.6%  10.7%
    Unexplned variance in 5th contrast =       1.3431   5.9%   9.6%
```

Figure 6. SFFTI Validity

In Figure 6, the value of raw variance explained by measures is 38.7%. This value is more than 20%, thus the SFFTI diagnostic test meets the validity of an instrument. This result is similar to research [7] which produces an index of more than 20%. The results of the reliability of the SFFTI diagnostic test are shown in Figure 7.

```
     SUMMARY OF 14 MEASURED Item
-------------------------------------------------------------------------------
|          TOTAL                          MODEL          INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE     S.E.      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN      49.8      34.3         .00      .23      1.02   -.21   1.00   -.28 |
|  SEM       4.1         .4        .24      .01       .12    .52    .12    .52 |
| P.SD      14.6       1.3         .85      .02       .44   1.89    .44   1.88 |
| S.SD      15.2       1.4         .89      .03       .46   1.96    .45   1.95 |
| MAX.      87.0      36.0         .96      .31      1.96   3.00   1.92   2.99 |
| MIN.      33.0      31.0       -2.28      .22       .43  -3.34    .42  -3.33 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .26 TRUE SD     .81  SEPARATION  3.12  Item   RELIABILITY  .91 |
|MODEL RMSE    .23 TRUE SD     .82  SEPARATION  3.50  Item   RELIABILITY  .92 |
| S.E. OF Item MEAN = .24                                                     |
-------------------------------------------------------------------------------
Item RAW SCORE-TO-MEASURE CORRELATION = -.99
Global statistics: please see Table 44.
UMEAN=.0000 USCALE=1.0000
```

Figure 7. SFFTI Reliability

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Figure 7 shows the value of reliability items 0.91 and 0.92, thus the reliability for the SFFTI diagnostic test is in the excellent category. These results are like research [12] which produces 81 and 86 reliability items which are categorized as good categories, and [23] which shows that the reliability score of 0.70 is included in the good reliability. Thus, the SFFTI diagnostic test is a reliable instrument. The level of difficulty is shown in Figure 8.

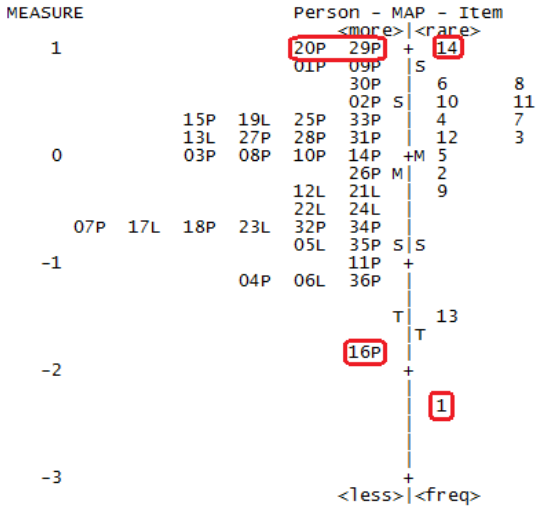

Figure 8. SFFTI Reliability

From Figure 8 shows on the right in the picture, code 1 or 2 shows the item number. On the left shows Brebes-Scholar, the L (*tole*) or P (*mbae*) code sequentially shows Brebes-Scholar male and female. All Brebes-Scholars can correctly answer question number 1. Problem number 1 is the easiest problem, while question number 14 is the most difficult problem for him. Brebes-Scholar with P code numbers 20 and 29 have high ability while female Brebes-Scholar number 16 has low ability.

After constructing and analyzing the quality of the SFFTI diagnostic test instrument, we tested the instrument on 36 Brebes-Scholar. After conducting the test, the data is then processed to find out the alternative conception of Brebes-Scholar based on the results of the test. The SFFTI trial results answered by Brebes-Scholar are then coded according to Table 1. After coding, we process the data by determining the percentage at each conception level (U, PU, NU, AC, and UC). Here is the percentage of Brebes-Scholar conception level in Figure 9.

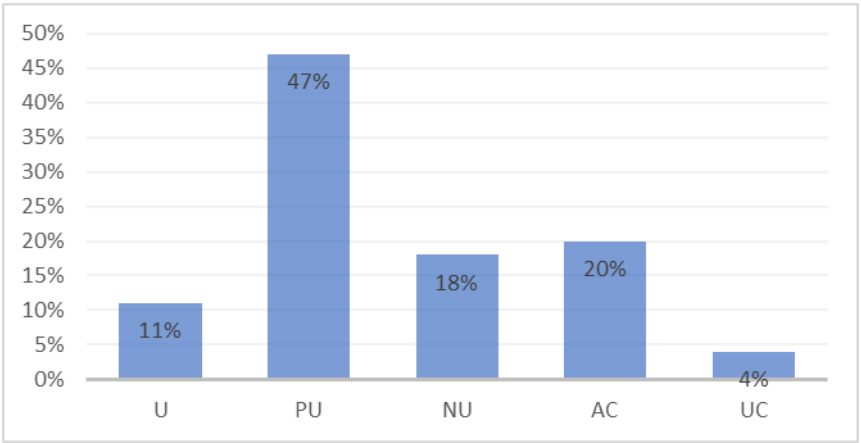

Figure 8. SFFTI reliability

Note: U= Understand, PU= Partial Understanding, NU= Not Understanding, AC= Alternative Concepts, UC= Un-Coded

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Figure 8 shows the percentage of Brebes-Scholar conceptions in the concept of static fluid. There are 11% experienced Understand (U), 47% experienced Partial Understanding (PU), 18% experienced Not Understanding (NU), 20% experienced Alternative Concepts (AC), and 4% experienced Un-Coded (UC). The highest percentages are Partial Understanding (PU) and Alternative Concepts (AC). This is consistent with research conducted by [24]. Partial Understanding (PU) has a higher percentage than Alternative Concepts (AC). This is because most scholars doubt the concept so they answer unsure of their level of trust. Some scholars even answered unsure for all levels of confidence in the questions.

The percentage of Brebes-Scholar alternative conceptions for each number on the SFFTI diagnostic test is shown in Figure 9.

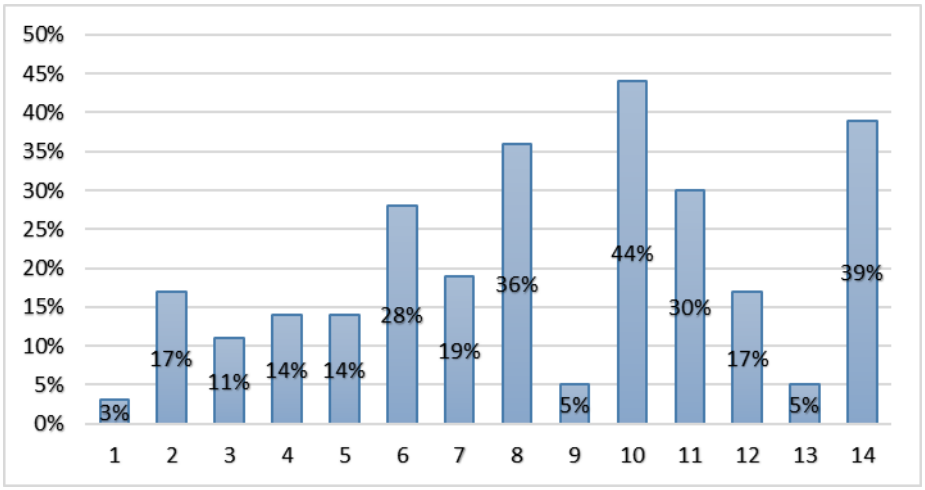

Figure 9. Brebes-Scholar alternative conceptions

In Figure 9 it can be seen that many Brebes-Scholar experienced alternative conceptions at number 10 (44%). While the least is number 1 (3%). An example problem in number 5 is what will happen if a driver will hit the brakes on a car. Most Brebes-Scholar answers the front wheel will be hit by the brakes because it is located close to the brake pedal. Brebes-Scholar does not relate this event to the concept of pressure in a closed space where the pressure will be continued in all directions equally. This is in line with research conducted [17] which states that scholars experience an alternative conception of the concept of fluid pressure in a closed system that cannot be continued in all directions equally.

4. Conclusion

From the results of the research conducted, the Static Fluid Four-Tier Instrument (SFFTI) developed by us is considered valid with a raw variance explained by measures of 38.7%, and reliable with item reliability values of 0.91 and 0.92 (very good). Thus, SFFTI can also identify Brebes-Scholar alternative conceptions on static fluid concepts, with a percentage of 20% experiencing alternative conceptions. Brebes-Scholar experienced many alternative conceptions at number 10 (44%). While the least is number 1 (3%). The most alternative conception is problem number 10 on the concept of pressure in a closed space. Brebes-Scholar considers that the fluid pressure in a closed space is not continued in all directions equally.

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