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# Factor Influencing Students' Scientific Literacy: An Exploratory Factor Analysis

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**Abstract**

Knowing what influences students' ability to understand and apply science in their daily lives will help with intervention planning and better understanding of the factors that influence students' scientific literacy. Thus, this study aimed to develop an instrument to identify factors contributing to students' scientific literacy. Four phases were employed to develop the instrument: conduct content validity, administer a pre-test, conduct construct validity using exploratory factor analysis, and determine construct reliability. A 131-item questionnaire was administered to 350 form four students aged 16 years old in daily government schools. Three constructs were subjected to exploratory factor analysis: the constructivist learning environment (CLE), attitude toward science (ATS), motivation, and self-efficacy (MSE). The five subconstructs of CLE are personal relevance, uncertainty, critical voice, shared control, and student negotiation. ATS comprises of seven subconstructs: social implications of science, normality of scientists, attitude to scientific inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science. Finally, MSE consists of three subconstructs: intrinsic motivation, extrinsic motivation, and self-efficacy. The instrument is expected to be useful in research and evaluation to measure factors influencing students' scientific literacy.

**Keywords:** Attitude, Motivation, Scientific Literacy, Factor Analysis

## Introduction

A scientific literate person is someone who can understand, apply, and be involved with issues, problems or arguments related to science and technology (OECD, 2016). Acquiring scientific literacy reflects students' ability to solve everyday problems at the individual and community levels scientifically (Fives et al., 2014; Choi et al., 2011).

Students' achievement in scientific literacy, measured through Trends in International Mathematics and Science Study (TIMSS) dan Programme for International Student Assessment (PISA), acts as a benchmark to a country's achievement and effectiveness in delivering the country's science education (MOE, 2013) against the other countries that participate in the international assessments. Malaysia participated in 1999, and Malaysia's ranking was above the international score in Mathematics and Science. However, Malaysia's participation in the latest TIMSS in 2015 saw that the performance of Malaysian students increased slightly compared to the previous year after two declines in 2007 and 2011.

Malaysia began participating in the PISA international examination in 2009. PISA assessed 74 countries and, once again, Malaysia's performance is dismal, ranking Malaysia in the bottom one-third of all participating countries. Malaysia's performance likewise falls short of the global and OECD averages. Malaysian students' science performance in PISA 2015 and 2018 improved slightly but remained below the OECD average (MOE, 2013; IEA, 2000, 2004, 2008, 2012, 2016).

**Factors Influencing Students' Scientific Literacy**

**Factor 1: Science Knowledge**. Science knowledge is a cognitive component emphasised while educating pupils to be scientifically literate (Halim, 2009 & Olubu 2015). According to the OECD (2018), scientific knowledge refers to the fundamental scientific concepts necessary for comprehending natural occurrences and the changes in nature caused by human activity. It encompasses both knowledge of science (knowledge of nature) and knowledge about science (knowledge of scientific processes). Scientific knowledge also includes the physical, biological, and chemical sciences and technology. Understanding the scientific process establishes the primary foundation for scientific inquiry. It entails the relevance of scientific theory, scientific investigation, quantitative and qualitative data measurement, and systematic steps for empirically and tentatively establishing evidence. Scientific knowledge is then created through scientific explanation, which involves presenting, arguing for, and generating new knowledge, methods, and concepts based on the data from scientific studies. Because it incorporates practical or hands-on science activities and experiments, the constructivist science laboratory learning environment is considered capable of developing students' scientific inquiry. According to Hofstein et al. (2004) and Moeed (2015), when these experiments or laboratory activities are designed effectively, the learning experience received by students can potentially improve their comprehension and knowledge of science, hence increasing students' scientific literacy.

**Factor 2: Constructivist Learning Environment**. The learning environment substantially impacts students' ability to enhance their scientific literacy (Techakosit & Wannapiroon, 2015). Students' roles have shifted in constructivist learning contexts, such as in science labs and 21st-century conceptual classrooms, from just receiving knowledge to building knowledge with the support of teachers (Halim, 2009 & Terhart, 2003). This learning environment teaches students to collaborate, take on various roles, advocate for ideas, and participate in decision-making. Teachers have a responsibility to conduct student-centred activities that will boost students' learning processes, develop their ability and critical thinking skills, and in turn, will improve their achievement (Terhart, 2003 & Bay et al., 2012). A constructivist learning environment produces active students who can plan effectively, solve issues, critique, and create practical connections in their daily lives (Terhart, 2003; Bay et a., 2012).

**Factor 3: Attitudes Toward Science**. Attitude is one of the factors influencing scientific literacy and the learning environment (Chionh & Fraser, 2009). According to Ajzen (2012), attitude plays a significant role in determining human behaviour. Most studies on scientific learning settings have discovered a correlation between science learning environments and attitudes toward science (Wahyudi & David, 2004; Telli et al., 2006). Students' attitudes toward science reflect their 'affective behaviours, including their acceptance, appreciation, and devotion to science. Research has established that the learning environment is a significant predictor of students' attitudes toward science (Aldoplhe et al., 2003; Karpudewan & Chong, 2017). Attitudes towards science are essential when considering scientific literacy (Bybee & McCrae, 2011). This attitude encompasses knowledge, emotion, and propensity for action. This component affects students' continuous interest in science and issues relating to science (Bybee & McCrae, 2011). Scientific literacy was the primary domain examined in the PISA 2009 assessment, and the assessment's definition of scientific literacy included features of individual attitudes toward science (OECD, 2010). However, research examining scientific literacy place a lesser emphasis on the attitude component as a primary component.

**Factor 4: Motivation and Self-Efficacy**. Research has also stressed the critical relationship between students' learning settings, science literacy, and motivation (Jackson & Davis, 2000; Aldridge et al., 2013). Motivation is a mental process that directs pupils' choices, efforts, and persistence. According to Pintrich & Schunk (2002), the learning environment provides students with a variety of options and loci of control to increase intrinsic motivation, increased levels of self-efficacy, goal orientation, and other types of motivation. Bandura's social cognitive theory of self-efficacy explains that students will take greater initiative to learn science if they can attain the required objectives (Bandura, 1986). Students who have a high sense of self-efficacy are more likely to exert considerable effort on a given task, monitor its progress, and employ self-regulation mechanisms (Schunk & Pajares, 2005). Students who appreciate science had a greater chance of achieving favourable learning outcomes and subsequent high results on scientific literacy examinations (McNeil, 2013) Additionally, studies demonstrate that groups of students who exhibit strong emotions toward science learning, such as enthusiasm, enjoyment, and involvement, achieve high levels of scientific literacy (Topcu et al., 2016).

Thus, this study aims to develop a questionnaire on factors that influence students' scientific literacy based on three primary constructs, namely constructivist learning environment (CLE), attitude toward science (ATS), motivation, and self-efficacy (MSE). At the same time, test questions will be used to measure constructs; science knowledge (SK) and scientific literacy (SL).

## Method

In this study, the construction of the instrument of factors influencing students ’scientific literacy is based on the following four steps:
Phase 1: Conduct content validity
Phase 2: Administer a pre-test
Phase 3: Use exploratory factor analysis for construct validity
Phase 4: Determine construct reliability

**Research Context**

350 form four students from daily government schools aged 16 years old were randomly selected. The sample involved ten schools in the state of Johor, and they had characteristics that were very similar to the actual study population. Table 1 shows the distribution of the respondents.

Table 1.
*Respondents' Background*

| **Background** | | **N** | **%** |
|---|---|---|---|
| Gender | Male | 136 | 38.9 |
| | Female | 214 | 61.1 |
| | Malay | 264 | 75.4 |
| | Chinese | 75 | 21.4 |
| Race | Indian | 10 | 2.9 |
| | Other | 1 | 0.3 |
| Type of class | Science | 201 | 57.4 |
| | Art | 149 | 42.6 |
| Science subject grade in national (PT3) examination | A | 65 | 18.6 |
| | B | 73 | 20.9 |
| | C | 77 | 22.0 |
| | D | 122 | 34.9 |
| | E | 10 | 2.9 |
| | F | 3 | 0.9 |

**Instrument Development**

***Phase 1: Conduct Content Validity***

Questionnaires will be used to measure construct constructivist learning environment (CLE), attitude toward science (ATS), motivation, and self-efficacy (MSE). In contrast, test questions will measure construct science knowledge (SK) and scientific literacy (SL).

Expert validity was conducted, with a lecturer from MOHE and two science educators from MOE serving as experts in science education. These experts verified the content of each item. They also verified the instrument's accuracy in terms of language and terminology, as it was adapted from the original survey and translated from English to Malay. Table 2 summarises the constructs examined in this study. study.

Table 2
*Construct, Subconstruct And Examples Of Items In The Questionnaire*

| Adaptation Sources | Subconstruct | No. of item | Example of items |
|---|---|---|---|
| **Constructivist Learning Environment (CLE)** | | | |
| Constructivist Learning Environment Survey (CLES) Taylor & Fraser (1991) | Personal Relevance | 6 | • My new learning starts with problems about the world outside of school. |
| | Uncertainty | 6 | • I learn that science cannot provide perfect answers to a problem. |
| | Critical Voice | 6 | • It is OK for me to ask the teacher why I have to learn this? |
| | Shared Control | 6 | • I help the teacher to plan what I'm going to learn. |
| | Student Negotiation | 6 | • I explain my understandings to other students |
| **Attitude Toward Science (ATS)** | | | |
| Test of Science Related Attitude (TOSRA) Fraser (1981); Kamisah, Zanaton & Lilia (2007) | Social implications of science | 10 | • Scientific discoveries are doing more good than harm. |
| | Normality of scientists | 10 | • Scientists do have enough time to spend with their families. |
| | Attitude to scientific inquiry | 10 | • Doing experiments is more good than finding out information from teachers. |
| | Adoption of scientific attitudes | 10 | • I like repeating experiments to check that I get the same results. |
| | Enjoyment of science lessons | 10 | • I would like to belong to a science club. |
| | Leisure interest in science | 10 | • Science lessons are fun. |
| | Career interest in science | 10 | • I would like to be a scientist after I leave school. |
| **Motivation and Self Efficacy (MSE)** | | | |
| Motivated Strategies for Learning *Questionnaire* (MSLQ) Pintrich, Smith, Garcia & McKeachie (1991) | Intrinsic motivation | 14 | • In a class like this, I prefer course material that really challenges me so I can learn new things. |
| | Extrinsic motivation | 9 | • Getting a good grade in this class is the most satisfying thing for me right now. |
| | Self-efficacy | 8 | • I'm confident I can learn the basic concepts taught in this course. |

As shown in Tables 3 and 4, experts were also asked to review each question to identify the type of knowledge for construct science knowledge and the type of competency for construct scientific literacy. The questions for science knowledge and scientific literacy was adapted from PISA scientific literacy assessment (OECD, 2013, 2016).

Table 3.
*Expert Review For Construct Science Knowledge*

| No. | Theme | Question | Type of science knowledge | | | |
|---|---|---|---|---|---|---|
| | | | **Biology** | **Chemistry** | **Physics** | **Technology** |
| 1 | Biodiversity | 1 | E1/E2/E3 | | | |
| | | 2 | E1/E2/E3 | | | |
| 2 | Cloning | 1 | | | | E1/E2/E3 |
| | | 2 | | | | E1/E2/E3 |
| | | 3 | | | | E1/E2/E3 |
| | | 4 | | | | E1/E2/E3 |
| 3 | Coral teeth | 1 | | E1/E2/E3 | | |
| | | 2 | | E1/E2/E3 | | |
| | | 3 | | E1/E2/E3 | | |
| 4 | Ultrasound device | 1 | | | E1/E2/E3 | |
| | | 2 | | | E1/E2/E3 | |

Table 4.
*Expert Review For Construct Scientific Literacy*

| No. | Theme | Question | Type of scientific literacy competency | | |
|---|---|---|---|---|---|
| | | | Identify scientific issues | Explain the phenomenon scientifically | Using scientific evidence |
| 5 | Drinking water | 1 | | E1/E2/E3 | |
| | | 2 | | E1/E3 | E2 |
| | | 3 | | E1/E2/E3 | |
| | | 4 | | E1/E2/E3 | |
| | | 5 | | | E1/E2/E3 |
| 6 | Stickleback behaviour | 1 | E1/E3 | | E2 |
| | | 2 | | | E1/E2/E3 |
| | | 3 | | | E1/E2/E3 |
| 7 | Smoking tobacco | 1 | E1/E2/E3 | | |
| | | 2 | | E1/E2/E3 | |
| | | 3 | | | E1/E2/E3 |
| | | 4 | | | E1/E2/E3 |
| 8 | Rat smallpox | 1 | | E1/E2/E3 | |
| | | 2 | E1/E2/E3 | | |
| | | 3 | E1/E2/E3 | | |
| 9 | Major surgery | 1 | E1/E2/E3 | | |
| | | 2 | | E1/E2/E3 | |
| | | 3 | E1/E2/E3 | | |
| | | 4 | | | E1/E2/E3 |
| 10 | Wind farm | 1 | E1/E2/E3 | | |
| | | 2 | | E1/E2/E3 | |
| | | 3 | | | E1/E2/E3 |
| | | 4 | | | E1/E2/E3 |

* E1: Expert 1; E2: Expert 2; E3: Expert 3

**Phase 2: Administer A Pre-Test**

A pre-test was administered on 46 respondents aimed to ascertain respondents' feedback on the items in the instrument. Students were briefed on the aims of the study and how to respond to the questions and questionnaire. It took 1 hour and 20 minutes to complete responding to all of the items.

**Phase 3: Using exploratory factor analysis for construct validity**

Exploratory Factor Analysis (EFA) is used to review the variety of indicators or subconstructs in the instrument. In this study, researchers have conducted EFA for CLE, ATS, and MSE instruments because these instruments have subconstructs to be tested. In exploratory factor analysis, (Hair et al., 2010) stated that items with a low factor loading ($\lambda<0.5$) would be phased out. EFA is used to determine the structure of latent variables formed from a set of variables. This EFA was implemented before testing the hypothesis. This analysis focused on applying data breakdown techniques to several factors to distribute the items according to their factors (Hair et al., 2010). In this study, EFA was conducted to identify the internal structure of 131 items for the CLE, ATS and MSE constructs. The process of designing an instrument involves exploring the subconstructs underlying the CLE, ATS and MSE.

### *Phase 4: Determine construct reliability*

Cronbach's alpha values were used to determine the reliability of each construct. The interpretation of the total score mean was offered, which was adapted from Nunnally (1997) interpretation.

## Findings

### EFA for Constructivist Learning Environment (CLE)

This construct includes 30 items that comprise five subconstructs or indicators: personal relevance, uncertainty, critical voice, shared control, and student negotiation. Each subconstruct consists of six items that will be assessed using the EFA. The Kaiser-Meyer-Olkin (KMO) and Bartlett's test values for CLE was conducted. The KMO value before item removal is 0.888 greater than 0.5, while Bartlett's test value is 0.000, which is greater than 0.05. Thus, supporting the factorability of the correlation matrix and suitable for factor analysis.

Based on the scree plot in Figure 1. there are five primary factors that contribute significantly to the overall variance in CLE.

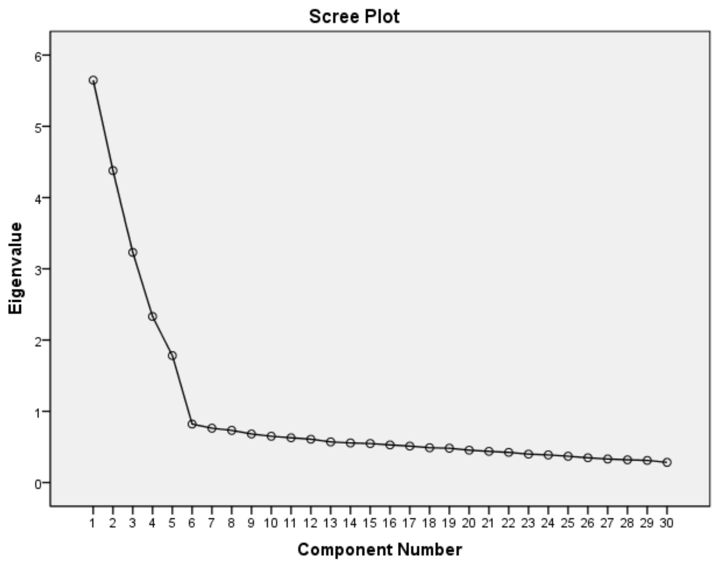


**Figure 1. Scree plot for CLE**

Five factors with eigenvalues greater than 1.0 were identified using principal component analysis. This factor contributes approximately 57.90% to the total number of the variance in construct CLE, as shown in the Table 5.

Table 5
*Total Variance Explained For For Cle*

| **Component** | **Initial Eigenvalues** | | | **Extraction Sums of Squared Loadings** | | |
|---|---|---|---|---|---|---|
| | **Total** | **% of variance** | **Cumulative %** | **Total** | **% of variance** | **Cumulative %** |
| 1 | 5.648 | 18.826 | 18.826 | 5.648 | 18.826 | 18.826 |
| 2 | 4.379 | 14.597 | 33.422 | 4.379 | 14.597 | 33.422 |
| 3 | 3.231 | 10.770 | 44.193 | 3.231 | 10.770 | 44.193 |
| 4 | 2.330 | 7.768 | 51.961 | 2.330 | 7.768 | 51.961 |
| 5 | 1.782 | 5.939 | 57.900 | 1.782 | 5.939 | 57.900 |
| 6 | .821 | 2.735 | 60.635 | | | |
| . | | | | | | |
| . | | | | | | |
| 30 | .283 | .944 | 100.000 | | | |

The Rotated Component Matrix demonstrated the relationship between the item and its factor after varimax rotation. Table 6 shows that the CLE variable contains five subconstructs, with all items belonging to their respective subconstructs and no items being confusing or belonging to other subconstructs. As a result, no items should be excluded from the CLE questionnaire.

Table 6
*Rotated Component Matrix For Cle*

| No | Item | Component | | | | |
|---|---|---|---|---|---|---|
| | | Shared control | Uncertainty | Critical voice | Personel relevance | Student negotiation |
| 1 | Pka22 | .813 | | | | |
| 2 | Pka20 | .812 | | | | |
| 3 | Pka21 | .808 | | | | |
| 4 | Pka23 | .789 | | | | |
| 5 | Pka24 | .786 | | | | |
| 6 | Pka19 | .783 | | | | |
| 7 | Pke11 | | .816 | | | |
| 8 | Pke9 | | .800 | | | |
| 9 | Pke8 | | .796 | | | |
| 10 | Pke12 | | .793 | | | |
| 11 | Pke7 | | .792 | | | |
| 12 | Pke10 | | .787 | | | |
| 13 | Psu16 | | | .749 | | |
| 14 | Psu14 | | | .748 | | |
| 15 | Psu15 | | | .745 | | |
| 16 | Psu18 | | | .710 | | |
| 17 | Psu13 | | | .699 | | |
| 18 | Psu17 | | | .672 | | |
| 19 | Pre4 | | | | .734 | |
| 20 | Pre3 | | | | .727 | |
| 21 | Pre5 | | | | .723 | |
| 22 | Pre2 | | | | .712 | |
| 23 | Pre1 | | | | .702 | |
| 24 | Pre6 | | | | .668 | |
| 25 | Pru28 | | | | | .715 |
| 26 | Pru27 | | | | | .697 |
| 27 | Pru29 | | | | | .686 |
| 28 | Pru26 | | | | | .674 |
| 29 | Pru30 | | | | | .642 |
| 30 | Pru25 | | | | | .633 |

**Exploratory Factor Analysis for Attitude Towards Science**

The attitude toward science includes 70 items comprising seven subconstructs as aforementioned. Each subconstruct consists of ten items that will be evaluated using the EFA. The KMO value for the ATS variable obtained was 0.934 which is greater than 0.50 indicating that the items are suitable for execution of factor analysis and the data have no problems with multicollinearity. The value of Bartlett's test of sphericity is 0.000, thus is significant at 0.05.

Based on the scree plot graph as shown in Figure 2 there are seven primary factors that contribute significantly to the overall variance in ATS.

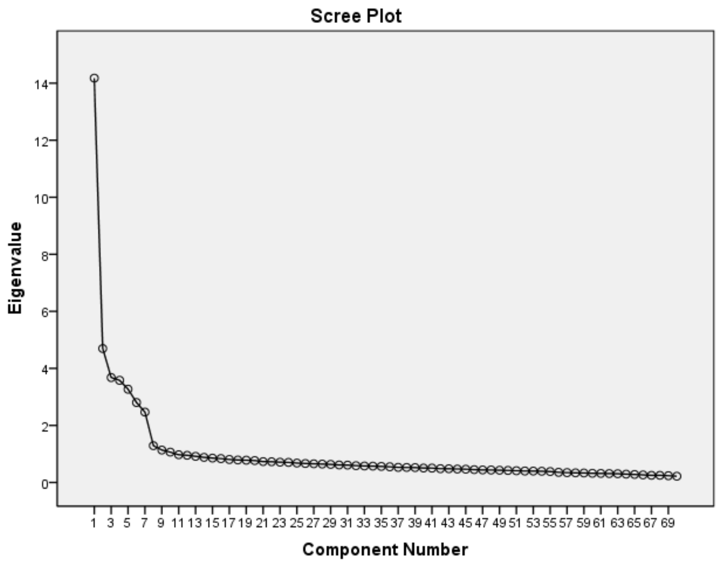


Figure 2. Scree plot for ATS

Table 7 shows the total variance explained for ATS by extracting it to seven main factors based on principal component analysis. The results of the seven-factor extract accounted for 49.53% of the overall variance change of the ATS variable.

Table 7
*Total variance explained for ATS*

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of variance | Cumulative % | Total | % of variance | Cumulative % |
| 1 | 14.177 | 20.252 | 20.252 | 14.177 | 20.252 | 20.252 |
| 2 | 4.696 | 6.708 | 26.961 | 4.696 | 6.708 | 26.961 |
| 3 | 3.680 | 5.257 | 32.217 | 3.680 | 5.257 | 32.217 |
| 4 | 3.581 | 5.116 | 37.333 | 3.581 | 5.116 | 37.333 |
| 5 | 3.269 | 4.671 | 42.004 | 3.269 | 4.671 | 42.004 |
| 6 | 2.803 | 4.004 | 46.008 | 2.803 | 4.004 | 46.008 |
| 7 | 2.467 | 3.524 | 49.532 | 2.467 | 3.524 | 49.532 |
| 8 | 1.290 | 1.843 | 51.375 | | | |
| . | | | | | | |
| . | | | | | | |
| 70 | .218 | .311 | 100.000 | | | |

The Rotated Component Matrix showed the correlation between the item and its factor after varimax rotation. Table 8 shows seven constructs in the ATS variable where all items belong to their respective subconstructs, and no items are confusing or belong to other subconstructs. Therefore, no items should be excluded from the ATS questionnaire.

Table 8
*Rotated component matrix for ATS*

| No | Item | Component | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Normality of scientists | Career interest in science | Leisure interest in science | Enjoyment of science lessons | Attitude to scientific inquiry | Social implications of science | Adoption of scientific attitudes |
| 1 | Sno16 | .785 | | | | | | |
| 2 | Sno58 | .774 | | | | | | |
| 3 | Sno51 | .753 | | | | | | |
| 4 | Sno9 | .746 | | | | | | |
| 5 | Sno30 | .732 | | | | | | |
| 6 | Sno65 | .728 | | | | | | |
| 7 | Sno2 | .725 | | | | | | |
| 8 | Sno44 | .720 | | | | | | |
| 9 | Sno37 | .719 | | | | | | |
| 10 | Sno23 | .716 | | | | | | |
| 11 | Smk63 | | .737 | | | | | |
| 12 | Smk49 | | .716 | | | | | |
| 13 | Smk14 | | .714 | | | | | |
| 14 | Smk56 | | .713 | | | | | |
| 15 | Smk21 | | .704 | | | | | |
| 16 | Smk42 | | .700 | | | | | |
| 17 | Smk7 | | .677 | | | | | |
| 18 | Smk70 | | .652 | | | | | |
| 19 | Smk28 | | .650 | | | | | |
| 20 | Smk35 | | .624 | | | | | |
| 21 | Smi48 | | | .752 | | | | |
| 22 | Smi55 | | | .751 | | | | |
| 23 | Smi41 | | | .701 | | | | |
| 24 | Smi13 | | | .697 | | | | |
| 25 | Smi27 | | | .675 | | | | |
| 26 | Smi34 | | | .662 | | | | |
| 27 | Smi20 | | | .657 | | | | |
| 28 | Smi6 | | | .642 | | | | |
| 29 | Smi69 | | | .623 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 30 | Smi62 | .609 | | | | |
| 31 | Sks40 | | .724 | | | |
| 32 | Sks47 | | .711 | | | |
| 33 | Sks12 | | .707 | | | |
| 34 | Sks26 | | .698 | | | |
| 35 | Sks61 | | .695 | | | |
| 36 | Sks68 | | .687 | | | |
| 37 | Sks54 | | .669 | | | |
| 38 | Sks5 | | .649 | | | |
| 39 | Sks33 | | .632 | | | |
| 40 | Sks19 | | .618 | | | |
| 41 | Ssi52 | | | .675 | | |
| 42 | Ssi24 | | | .656 | | |
| 43 | Ssi59 | | | .650 | | |
| 44 | Ssi31 | | | .647 | | |
| 45 | Ssi17 | | | .639 | | |
| 46 | Ssi66 | | | .620 | | |
| 47 | Ssi3 | | | .619 | | |
| 48 | Ssi10 | | | .616 | | |
| 49 | Ssi38 | | | .566 | | |
| 50 | Ssi45 | | | .559 | | |
| 51 | Sim43 | | | | .657 | |
| 52 | Sim29 | | | | .644 | |
| 53 | Sim36 | | | | .636 | |
| 54 | Sim57 | | | | .613 | |
| 55 | Sim50 | | | | .594 | |
| 56 | Sim22 | | | | .593 | |
| 57 | Sim15 | | | | .585 | |
| 58 | Sim1 | | | | .583 | |
| 59 | Sim64 | | | | .575 | |
| 60 | Sim8 | | | | .560 | |
| 61 | Sad60 | | | | | .706 |
| 62 | Sad46 | | | | | .604 |
| 63 | Sad39 | | | | | .590 |
| 64 | Sad4 | | | | | .590 |
| 65 | Sad18 | | | | | .581 |
| 66 | Sad11 | | | | | .578 |
| 67 | Sad25 | | | | | .566 |
| 68 | Sad32 | | | | | .556 |
| 69 | Sad67 | | | | | .551 |
| 70 | Sad53 | | | | | .504 |

**Exploratory Factor Analysis for Motivation (MSE)**

For the construct of MSE, there are 31 items that represent three subconstructs: intrinsic motivation, extrinsic motivation, and self-efficacy. Intrinsic motivation consists of 14 items, extrinsic motivation with 9 items, and self-efficacy consists of 8 items that will be screened using the EFA test. The KMO value was 0.920, which was greater than 0.50

and Bartlett's value was 0.000, which was smaller than 0.05, which indicated that the correlation between the items was suitable for factor analysis.

To determine the number of subconstruct in MSE, the researcher has referred to the scree plot graph as shown in Figure 3. According to the graph, there are three primary factors that contribute significantly to the overall variance in MSE.

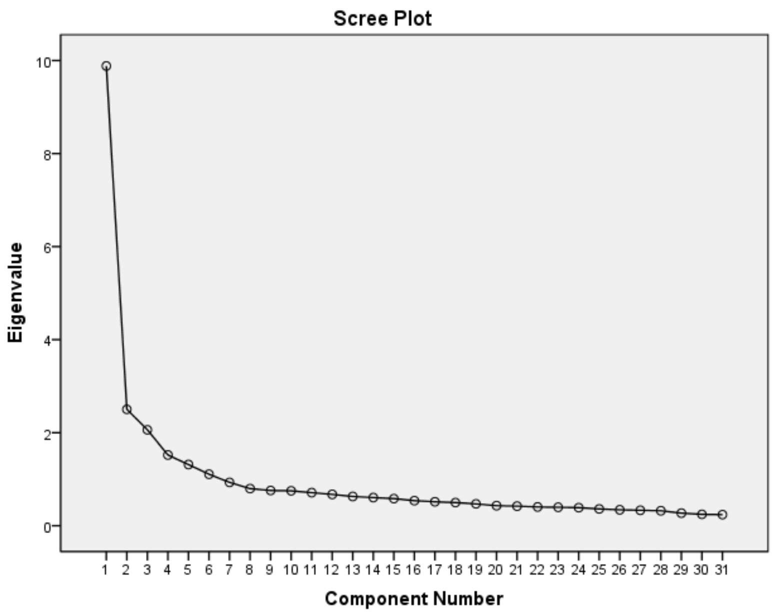


**Figure 3. Scree plot for MSE**

Table 9 shows the total variance explained for MSE by extracting it to three main factors using principal component analysis. The results of the three-factor extract accounted for 46.60% of the overall variance change of the MSE variable.

Table 9
*Total variance explained for MSE*

| **Component** | **Initial Eigenvalues** | | | **Extraction Sums of Squared Loadings** | | |
|---|---|---|---|---|---|---|
| | **Total** | **% of variance** | **Cumulative %** | **Total** | **% of variance** | **Cumulative %** |
| 1 | 9.883 | 31.879 | 31.879 | 9.883 | 31.879 | 31.879 |
| 2 | 2.502 | 8.071 | 39.950 | 2.502 | 8.071 | 39.950 |
| 3 | 2.061 | 6.650 | 46.600 | 2.061 | 6.650 | 46.600 |
| 4 | 1.520 | 4.904 | 51.504 | | | |
| . | | | | | | |
| . | | | | | | |
| 31 | .239 | .771 | 100.000 | | | |

The Rotated Component Matrix showed the correlation between the item and its factor after varimax rotation. Table 10 shows that there are three subconstructs in the MEK variable where all items belong to their respective subconstructs. There are two items that are confusing or belong to other subconstructs, namely MiK4 and MiK25 items. Therefore, such items should be excluded from the MEK questionnaire.

Table 10.
*Rotated Component Matrix For Mse*

| No | Item | Component | | |
|---|---|---|---|---|
| | | Intrinsic motivation | Self-efficacy | Extrinsic motivation |
| 1 | MiK23 | .754 | | |
| 2 | MiK10 | .721 | | |
| 3 | MiK27 | .715 | | |
| 4 | MiK18 | .686 | | |
| 5 | MiK17 | .672 | | |
| 6 | MiK26 | .662 | | |
| 7 | MiK16 | .657 | | |
| 8 | MiK22 | .644 | | |
| 9 | MiK2 | .637 | | |
| 10 | MiK9 | .625 | | |
| 11 | MiK4 | .578 | .315 | |
| 12 | MiK25 | .561 | | .302 |
| 13 | MiK1 | .551 | | |
| 14 | MiK24 | .542 | | |
| 15 | EF20 | | .698 | |
| 16 | EF15 | | .692 | |
| 17 | EF29 | | .673 | |
| 18 | EF5 | | .654 | |
| 19 | EF6 | | .638 | |
| 20 | EF21 | | .626 | |
| 21 | EF31 | | .625 | |
| 22 | EF12 | | .599 | |
| 23 | Meks30 | | | .431 |
| 24 | Meks14 | | | .732 |
| 25 | Meks19 | | | .732 |
| 26 | Meks28 | | | .732 |
| 27 | Meks3 | | | .666 |
| 28 | Meks8 | | | .611 |
| 29 | Meks11 | | | .541 |
| 30 | Meks13 | | | .486 |
| 31 | Meks7 | | | .359 |

**Reliability Analysis**

Each factor values of Cronbach alpha falls between 0.71 to 0.90. As seen in Table 11, each value indicated that all elements demonstrated good reliability.

Table 11
*Cronbach's Alpha Value*

| Construct | Subconstruct | Bil. Item | Cronbach's alpha value |
|---|---|---|---|
| Constructivist learning environment (CLE) | Personal Relevance | 6 | 0.84 |
| | Uncertainty | 6 | 0.89 |
| | Critical Voice | 6 | 0.85 |
| | Shared Control | 6 | 0.88 |
| | Student Negotiation | 6 | 0.83 |
| Attitude toward science (ATS) | Social implications of science | 10 | 0.83 |
| | Normality of scientists | 10 | 0.85 |
| | Attitude to scientific inquiry | 10 | 0.89 |
| | Adoption of scientific attitudes | 10 | 0.80 |
| | Enjoyment of science lessons | 10 | 0.89 |
| | Leisure interest in science | 10 | 0.90 |
| | Career interest in science | 10 | 0.89 |
| Motivation and self-efficacy (MSE) | Intrinsic motivation | 12 | 0.89 |
| | Extrinsic motivation | 9 | 0.78 |
| | Self-efficacy | 8 | 0.84 |
| Scientific literacy | Identify scientific issues | 15 | 0.71 |
| | Explain the phenomenon scientifically | 17 | 0.72 |
| | Using scientific evidence | 28 | 0.75 |
| Science Knowledge | | 19 | 0.71 |

**Interpretation of Total Score Mean**

The questionnaire or instrument was based on a five-point Likert scale to gauge respondents' views on the three main constructs: constructivism learning environment, attitudes toward science, motivation, and self-efficacy. Mean scores for each construct were computed based on Nunnally and Bernstein (1994) interpretation of total score mean which were low (score mean: 1.00-2.00), medium-low (score mean: 2.01-3.00), medium-high (score mean: 3.01-4.00) and high (score mean: 4.01-5.00).

**Discussion And Implication**

This study developed a survey instrument to determine the factors influencing students' scientific literacy which was based on previous instruments Taylor and Fraser (1991), Fraser (1981), Osman et al. (2007) and Pintrich et al. (1991), while the test question instrument was based on PISA scientific literacy assessment (OECD, 2013, 2016). The study also adopted the Bandura's Social Cognitive Theory (Bandura, 1986) that was integrated with the Huitt's Teaching and Learning Model Huitt (2021) and PISA Scientific Literacy Model (OECD, 2013).

A total of 129 items for construct CLE, ATS, and MSE was developed. In the development of the instrument phase, validity and reliability analyses were performed on 131 items due to expert evaluations. The content validity was obtained from experts while construct validity was established through EFA. As a result of EFA, it was found that the construct CLE had five subconstructs, and it explained 57.90% of the total variance;

construct ATS had seven subconstructs, and it explained 49.53% of the total variance; while constructs MSE had three subconstructs that explained 46.60% of the total variance. The EFA results indicated that the scale had a valid structure. In addition, based on the Cronbach's alpha values that measure the internal consistency of items, it was concluded that the scale was reliable.

The developed instrument's validity and reliability will be improved in future studies if the identified factors are subjected to CFA analysis. A model of students' scientific literacy can be constructed using the findings of this study. Interventions aimed at improving students' scientific literacy should take these considerations into account when devising a strategy. Understanding the factors that influence students' scientific literacy will help us better understand how to enhance people's knowledge about science and apply science in their everyday lives.

Construct validity is a critical step in developing a scientific questionnaire measurement scale. Construct validity essentially grows over time, and this scale needs further adjustment to improve its reliability and ability to explain variance across contexts, cultures, and conditions. A suggestion for future research is to look into a random sample size, generalisation, and model validity.

## Conclusion

Exploratory factor analysis was used to establish the validity of the proposed constructs. The developed instrument, based on the empirical data, comprised of validated measures of factors that influence students' scientific literacy in the context of science education research. This study offers several research implications and directions for academics and practitioners looking to learn more about the factors that influence students' scientific literacy. Overall, according to EFA, the CLE has five constructs, the ATS has seven constructs, and the MSE has three constructs with a total of 129.

Based on the exploratory factor analysis in the measurement model, it can contribute to providing additional research on the structural model of scientific literacy by supporting and confirming the variables found in Bandura's Social Cognitive Theory and supporting the claims that there is a reciprocal relationship between: (i) personal factors such as motivation and self-efficacy; (ii) attitude toward science; and (iii) a constructivist learning environment. The factors that affect scientific literacy are also in line with the PISA Scientific Literacy Model, which shows how important factors like students' attitudes, knowledge, and the learning environment they are in affect their scientific literacy. For example, if teachers want to improve students' attitudes toward science, they must carry out activities that apply scientist characteristics, activities that pique students' interest in science, adapt scientific attitudes, and carry out investigational activities. Teachers must address these factors to develop students with scientific literacy ability.

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