International Journal of Academic Research in Business and Social Sciences
2017, Vol. 7, No. 6
ISSN: 2222-6990

Fuzzy Delphi Method for Content Validation of Integrated Science Process Skills Instrument

Ellyza Karim, Dr. Jamil Ahmad & Prof. Kamisah Osman
Faculty of Education, National University of Malaysia, Bangi, Malaysia

DOI: 10.6007/IJARBSS/v7-i6/3037 URL: http://dx.doi.org/10.6007/IJARBSS/v7-i6/3037

Abstract
The purpose of this paper is to obtain expert consensus on the writing of relevant items which allied their competency indicators of integrated science process skills. There are five constructs of integrated science process skills, namely formulating hypotheses, defining operationally, identifying and controlling variables, interpreting data, and experimenting. Verification is done by 13 experts in the field of science education using structured questionnaire aiming to validate the items-indicators to gain response about form one student's ability on integrated science process skills. Questionnaire containing 26 items of 5-point Likert scale was given to experts. Consensus from the experts was further analysed using Fuzzy Delphi method. The study found that expert consensus on the items-indicators of integrated science process skills were more than 75% with the threshold value (d) ≤ 0.2 and α-cut value ≥ 0.5.
Keywords: Fuzzy Delphi Method, Integrated Science Process Skills, Science Process Skills, Content Validation, expert Consensus.

Introduction

Fuzzy Delphi Method (FDM) is a combination between Fuzzy set theory and traditional Delphi technique to overcome the weakness of the existing Delphi Method (Chang, Hsu & Chang, 2011). According to Cheng and Lin (2002), long range forecasting in Delphi Method is responsible for introducing problems related to imprecise and incomplete data information. Also the decisions made by the experts rely on their individual competence and are subjective. Therefore, it is more proper to present the data by fuzzy numbers instead of crisp numbers. This is how fuzzy Delphi method is more relevant than Delphi method in real world.

The application of FDM is used in this study specifically to validate the content instead of other validation phases on instrument development which are face validity, construct validity and criterion validity. However, this article will only touch on content validation using FDM as the analysis method. Thirteen experts among science educators from all Malaysian educational institutions are formally invited to obtain their consent to fill in the questionnaire. A total of 26 items were included in the 5-point Likert scale instrument categorised into strongly disagree to strongly agree. Questionnaire is a useful tool as interviewing experts are hardly executed due to group arrangement, location and time.

Scientifically literate students must be competent in using science process skills (Chiappetta & Koballa 2006). What are the science process skills (SPS)? They are the things that scientists do when they study and investigate (Rezba et al. 1995). SPS is a reflection of methods used by scientists while generating information on science. The SPS include intellectual skills, associated psychomotor and affective skills that are concerned with the learning of science in all its aspects (Sheeba, 2013). Teaching the process of science means going beyond the content to help students understand science by 'doing' it using the tools they need to think scientifically. Curriculum Development Centre (2013) categorised twelve SPS into basic and integrated. Seven basic SPS are observing, inferring, predicting, classifying, measuring, using space and time relationship and communicating. Five integrated SPS are formulating hypotheses, defining operationally, identifying and controlling variables, interpreting data and experimenting. Table 1 shows the definition for the five constructs of integrated science process skills (ISPS) involved in this study.

Table 1 Definition of five ISPS constructs

ISPS	Definition	Sources
Defining operationally	Developing statements that present a concrete description of an object or an event by telling one what to do or observe	Chiappetta & Koballa, 2006
Interpreting data	Organizing and analysing data that have been obtained by collecting bits of information about objects and events that illustrate a specific situation, and drawing conclusions from it by determining apparent patterns or relationships in the data.	Sheeba, 2013
Formulating hypotheses	Relating manipulated variable with responding variable. Stating the expected outcome of an experiment	Abu Hassan & Rohana, 2003 Padilla, 1990
Identifying and controlling variables	Ability to identify variables (recognizing the characteristics of objects or factors in events) that are constant or change under different conditions, and that can affect an experimental outcome keeping most constant while manipulating only one (the independent) variable	Sheeba, 2013
Experimenting	Testing a hypothesis through the manipulation and control of independent variables and noting the effects on a dependent variable, interpreting and presenting results in the form of a report that others can follow to replicate the experiment	Chiappetta & Koballa, 2006

Since 1980s eras, researchers from all over the world developed multiple question instruments to evaluate SPS. The most popular is the Test of Integrated Process Skills (TIPS) by Dillashaw and Okey (1980). TIPS was then further modified as TIPS II by Burns, Okey and Wise (1985) which are referred as the main source to other science process skills instrument developer. Even lately in Malaysia, *Universiti Perguruan Sultan Idris* (UPSI) and *Universiti*

Kebangsaan Malaysia (UKM) are actively developing those kinds of instruments (for example; Ong et al., 2015; Ong & Mohd. Al-Junaidi, 2013; Ong et al., 2012; Edy Hafizan & Lilia, 2010). However, none of those instruments were designed specifically to assess indicators contained in table 2. Table 2 shows at least three items developed for each ISPS construct in accordance to the chosen indicators among the total of 26 items.

Table 2 Indicators specification table for ISPS constructs

ISPS	Competency indicators	Item number
Defining operationally	• Defining terms/concept/variable based on personal experience • Defining terms/concept/variable in the context of findings • Defining terms/concept/variable by describing what is done and observed	1 2 3
Interpreting data	• Discuss what they find in relation to their initial question or hypothesis • Draw conclusions which summarised and are consistent with all the evidence that has been collected • Analysing findings based on the data gathered • Identify patterns or trends from the observations or measurements • Able to identify factor causing the bias investigation • Able to state relationship between information	4 5 6 7 8 9
Making hypotheses	• Identifying relationship between manipulated and responding variables • Making explanations using previous knowledge • Show awareness that there may be more than one explanation that fits the evidence • Show awareness that explanations are tentative and never proved beyond doubt	10 11 12 13
Identifying and controlling variables	• Identifying what needs to be measured on responding variable • Identifying what needs to be unchanged on constant variable • Identifying what needs to be done on manipulated variable • Differentiating between responding, constant and manipulated variables	14 15 16 17
Experimenting	• Presenting question based on identified problem • Making testable hypothesis	18 19

	• Select and use appropriate apparatus	20
	• Designing procedure scientifically	21
	• Writing experiment description accurately	22
	• Carrying out experiment to test the hypothesis	23
	• Collecting the data honestly	24
	• Making conclusion based on the data collected	25
	• Reporting experiment results	26

Each item was developed by referring to the indicators revised from UNESCO primary source book by Harlen and Elstgeest (1992), Malaysian curriculum emphases article by Yeoh and Gan (2004) and Harlen (2006) published book. Contents for all the items were based on KSSR science syllabus and the target respondents are the first KSSR cohort of 2016 UPSR leavers. Due to the comments and suggestions from the experts, some of the items were being modified in order to produce right question, suitable wordings and to make sure that the context, sequence and response categories help the respondent without unintentionally biasing the feedbacks (Oppenheim, 2009).

Likert scale rating instrument is an appropriate tool to measure students' SPS ability using validated competency indicators rather than multiple choice test. The items developed which tally the indicators are kind of validated suggestion. However teachers may change the items accordingly by the topic they teach in classroom but keep tally to the indicators. Overall, the items for this instrument is built randomly within KSSR topics which implemented since 2011 to 2016.

Literature Review

Based on the literature study of FDM usage from various perspectives, Nazirah et al. (2015) found FDM is a good and accepted method in obtain the consensus of experts. For this study, experts consensus are needed to verify the content on ISPS items-indicators instrument created for form one students or specifically the primary evaluation test leavers; *Ujian Penilaian Sekolah Rendah* (UPSR) on 2016. These particular students are the first cohort of the latest implemented primary science curriculum, namely *Kurikulum Sains Sekolah Rendah* (KSSR) syllabus. Identification of an expert is important in any study involving expertise. The experts selected their degree of agreement for each item in the questionnaire. Then the proportion of agreement selected by experts provided a measure of consensus using FDM formula.

Shanteau et al. (2000) listed few criteria to select experts including teaching experience, certification and social acclimation. In the context of this study, the number of years of job relevant experience is used as a surrogate for expertise. Participants in this study possessed twelve to thirty seven years of experience in teaching science at primary schools, secondary schools, teaching institutes, and universities. Furthermore, some of the participants are officially granted as professor, head of science department, excellence lecturer, master trainer, and unofficial offers as book writers and invited speakers.

SPS is evaluated at school using practical skill assessment, namely *Pentaksiran Kemahiran Amali* (PEKA). Nevertheless, there are some weakness in terms of time constraint and burdensome task to teachers as it is common to have 40 to 50 students per class during science lesson (Edy Hafizan & Lilia, 2010) with allocation time of one and a half hours per week. Even though there are so many tools to assess PEKA but appropriately, teachers just managed to use observation and questioning technique (Mat Rasid, 2014). Hence a suitable tool is needed to assist teacher in SPS assessment.

In order to gauge primary students' science process skills ability, development and validation of specific instrument is crucial important because based on the literature review, there was no study done with such aim. There are several commonly used multiple-choice format instruments but most of it aiming to measure basic SPS as shown in table 3. PEKA can be used to measure students' ability but in term of check list for certain elements based on teachers' observation. Through PEKA, seven elements in basic and integrated science process skills are assessed; observing, classifying, measuring using numbers, communicating, using space/time relations, defining terms operationally and experimenting. However, controlling variables, formulating hypothesis and interpreting data are embodied in the experimenting element. So, it is time to develop an instrument focusing on ISPS itself using underlined indicators verified by experts. Add more vital, the response comes from students themselves thus, reducing teachers burden to observe repeatedly in long periods.

Table 3 Instruments development for assessing SPS

Researcher	Origin	Year	SPS no.	Instrument format
Ludeman et al.	USA	1975	5	Multiple-choice
Okey & Dillashaw	USA	1980	5	Multiple-choice
Burns, Okey & Wise	USA	1985	5	Multiple-choice
Smith & Welliver	USA	1990	13	Multiple-choice
Beaumont-Walters & Soyibo	Jamaica	2001	5	Practical Structure
Abu Hassan & Rohana	Malaysia	2003	6	Structure Multiple-choice
Kazeni	South Africa	2005	5	Multiple-choice
Temiz, Tasar & Tan	Turkey	2006	12	Multiple-choice
Edy Hafizan & Lilia	Malaysia	2010	5	Multiple-choice
Ong Eng Tek et al.	Malaysia	2012	12	Multiple-choice
Edy Hafizan	Malaysia	2012	5	Multiple-choice Interview
Ong Eng Tek & Mohd Al-Junaidi	Malaysia	2013	12	Multiple-choice
Ong Eng Tek et al.	Malaysia	2015	7	Multiple-choice

METHODOLOGY

Survey questionnaire is administered upon thirteen experts as specified in table 4. According to Adler and Ziglio (1996), suitable number of experts in Delphi method is between ten to fifteen for the high consensus achieved while Jones and Twiss (1978) suggested between ten to fifty.

Table 4 Experts specification

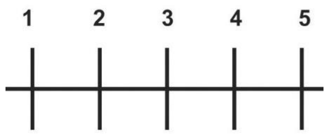
Area	**Experts numbering**
Primary schools	3,9
Secondary school	10
Teaching institutes	1,4,6,8,11
Public universities	7,12,13
Private universities	2
Curriculum Development Centre	5

Items developed by researcher are presented to experts in the questionnaire next to the indicators. To verify that items are in accordance with those indicators, expert views are needed to produce such instrument. In the first phase, an expert is appointed for the face validity followed by a group of experts for the content validation. Then for the second phase, after the administration of the instrument at school, factor analysis will verify the construct validation plus Rasch model to validate the items in depth. Item validation via Rasch model will analyze in terms of item polarity, item-person fitness, separation index, item dimension, item difficulty, reliability and scale calibration. Final phase is to check the correlation of this instrument with the readily instruments out there to find the criterion validation, specifically the concurrent and prediction validity. However, this article will only touch on the first phase which is the content validation part.

As an example of controlling variables construct, item 14 designed for the indicator to identify what needs to be measured on responding variable. The item is “Identifying ___________________ as the responding variable for shadow experiment when a pencil is located under the sun shine from 7 a.m. to 12 p.m.”. Picture 1 is provided to students.

Picture 1

Students need to circle one of the Likert scale point ranged from 1 to 5 labelled as unable to able. The ability ratings increase as the number increase. Picture 2 shows the interval scale for students’ instrument. The relevant to follow-up students with open item is to make sure students know whether they have or not the competency on the indicator of ISPS. Student will choose unable if they cannot answer the item or able if they know they can answer the item. Krosnick and Presser (2009) given an example of Schuman (1972) study using both open and closed questions which is, open questions can add richness to survey results that is difficult, if not impossible, to achieve with closed questions. So including both type of questions on their own or as follow-up to closed items can yield significant benefit.



unable able

Picture 2

However for FDM, content validation by the experts was just assessed using close questions, a 5-point Likert scale categorised into strongly disagree to strongly agree questionnaire. The score of experts' agreement on the 26 items-indicators were then converted into triangular fuzzy numbers based on the experts' responses as shown in Table 5.

Table 5 Category for the agreement of items-indicators

Category	**Likert scale**	**Fuzzy scale**
Strongly disagree	1	(0.0, 0.0, 0.2)
Disagree	2	(0.0, 0.2, 0.4)
Less agree	3	(0.2, 0.4, 0.6)
Agree	4	(0.4, 0.6, 0.8)
Strongly agree	5	(0.6, 0.8, 1.0)

Research Question

What are the consensus of the experts among ISPS items in terms of five constructs such as defining operationally, interpreting data, formulating hypothesis, identifying and controlling variables and experimenting?

Data Analysis and Discussion

Upon the feedbacks from a group of selected expert, threshold value, (d), are calculated using the following formula (Chen, 2000):

$$d\left(\tilde{m},\tilde{n}\right)=\sqrt{\frac{1}{3}\left[(m_1-n_1)^2+(m_2-n_2)^2+(m_3-n_3)^2\right]}$$

In this study, the criterion used to measure expert consensus were based on three conditions. First, the d value must be equal or less than 0.2 (Cheng & Lin, 2002) and second, group agreement percentage is greater than 75% (Chu & Hwang, 2008). Third, according to Tang and Wu (2010), the average of Fuzzy number which is the A value must exceed 0.5 using the formula $A = 1/3 \times (m_1+m_2+m_3)$. For that, the items are accepted if all requirements were achieved.

Table 6 Average Fuzzy rating for defining operationally

Experts	**Items**		
	1	**2**	**3**
1	0.09	0.19	0.12
2	0.09	0.12	0.12
3	0.09	0.12	0.19
4	0.09	0.12	0.19
5	0.40	0.49	0.12
6	0.09	0.12	0.19
7	0.21	0.12	0.19
8	0.21	0.12	0.42
9	0.09	0.19	0.19
10	0.21	0.12	0.19
11	0.09	0.19	0.12
12	0.21	0.12	0.42
13	0.21	0.12	0.19
d items	**0.16**	**0.16**	**0.20**
% items	**92%**	**92%**	**85%**
A scores	**0.66**	**0.72**	**0.68**

Table 7 Average Fuzzy rating for interpreting data

Experts	Items					
	4	**5**	**6**	**7**	**8**	**9**
1	0.07	0.14	0.10	0.07	0.21	0.07
2	0.68	0.16	0.10	0.23	0.21	0.23
3	0.24	0.16	0.21	0.23	0.21	0.07
4	0.07	0.14	0.21	0.68	0.21	0.23
5	0.07	0.45	0.98	0.95	0.98	0.95
6	0.24	0.14	0.21	0.23	0.21	0.38
7	0.24	0.16	0.21	0.23	0.21	0.23
8	0.07	0.16	0.21	0.23	0.10	0.23
9	0.24	0.16	0.21	0.07	0.10	0.07
10	0.24	0.16	0.21	0.23	0.21	0.23
11	0.07	0.14	0.10	0.07	0.10	0.07
12	0.38	0.14	0.40	0.23	0.40	0.23
13	0.24	0.16	0.21	0.23	0.21	0.23
d items	**0.22**	**0.18**	**0.26**	**0.29**	**0.26**	**0.25**
% items	**85%**	**92%**	**85%**	**85%**	**85%**	**85%**
A scores	**0.65**	**0.69**	**0.67**	**0.65**	**0.67**	**0.65**

As stated in table 6 to 10, threshold values, d are calculated between 0.14 to 0.29, meaning all experts are considered to have achieved a consensus. Furthermore, the percentage of achieving a group consensus for all five constructs are greater than 75% which are in the range of 77% to 100% and all the A scores exceed 0.5 with 0.65 as the smallest value. So, all the items-indicators in all five constructs were considered accepted by all the experts.

Table 8 Average Fuzzy rating for formulating hypothesis

Experts	Items			
	10	**11**	**12**	**13**
1	0.45	0.16	0.19	0.19
2	0.17	0.16	0.19	0.19
3	0.17	0.14	0.12	0.12
4	0.15	0.14	0.12	0.12
5	0.15	0.16	0.19	0.19
6	0.17	0.14	0.12	0.12
7	0.17	0.16	0.12	0.12
8	0.17	0.14	0.12	0.12
9	0.17	0.14	0.12	0.12
10	0.17	0.14	0.12	0.12
11	0.15	0.16	0.19	0.19
12	0.76	0.16	0.19	0.19
13	0.17	0.14	0.12	0.12
d items	**0.23**	**0.15**	**0.15**	**0.15**
% items	**85%**	**100%**	**100%**	**100%**
A scores	**0.70**	**0.71**	**0.72**	**0.72**

Even though expert 1 and 12 calculated fuzzy ratings exceed 0.2 on item 10 but based on the average fuzzy rating calculation, all the threshold value on formulating hypothesis construct has achieved group consensus. Indeed, the percentage of achieving group consensus for this construct is the highest among the five ISPS. Item 11, 12 and 13 stated 100% agreement. Third rules in Fuzzy Delphi also accepted whereas all the A scores exceed 0.5. Here are some examples of items for formulating hypothesis construct that match the delineated indicators:

Item no	**Indicator**	**Item**
10	Identifying relationship between manipulated and responding variables	"As the temperature **increase/decrease**, the rate of ice melt become faster/slower".
11	Making explanations using previous knowledge	Time taken for the water rocket to be in air is longer if the volume of water inside the bottle **increase/decrease**.
12	Show awareness that there may be more than one explanation that fits the evidence	Coarse sugar is easily diluted in hot water but hardly diluted in room temperature water. Other condition to increase sugar dilution is: ……………………………………………………………………………….
13	Show awareness that explanations are tentative and never proved beyond doubt	Hypotheses in item 10 can also be written as: "As the temperature .... the rate of ice melt become...........................".

Table 9 Average Fuzzy rating for identifying and controlling variables

Experts	Items			
	14	**15**	**16**	**17**
1	0.43	0.13	0.69	0.11
2	0.75	0.13	0.14	0.11
3	0.19	0.19	0.23	0.22
4	0.13	0.43	0.42	0.40
5	0.19	0.19	0.23	0.11
6	0.19	0.19	0.23	0.22
7	0.19	0.19	0.23	0.22
8	0.19	0.19	0.23	0.22
9	0.19	0.13	0.14	0.11
10	0.19	0.19	0.23	0.22
11	0.13	0.13	0.14	0.11
12	0.43	0.75	0.69	0.73
13	0.19	0.19	0.23	0.22
d items	**0.26**	**0.24**	**0.29**	**0.23**
% items	**77%**	**85%**	**77%**	**85%**
A scores	**0.69**	**0.69**	**0.68**	**0.67**

Table 10 Average Fuzzy rating for experimenting

Experts	Items								
	18	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
1	0.14	0.14	0.09	0.12	0.19	0.19	0.16	0.21	0.52
2	0.14	0.14	0.09	0.12	0.12	0.12	0.16	0.09	0.09
3	0.16	0.16	0.09	0.12	0.12	0.12	0.14	0.09	0.09
4	0.16	0.16	0.09	0.19	0.12	0.12	0.16	0.09	0.09
5	0.45	0.14	0.21	0.19	0.19	0.19	0.14	0.21	0.09
6	0.16	0.14	0.09	0.12	0.12	0.12	0.16	0.09	0.09
7	0.16	0.16	0.09	0.12	0.12	0.12	0.16	0.09	0.09
8	0.16	0.16	0.09	0.12	0.12	0.12	0.45	0.09	0.09
9	0.16	0.16	0.09	0.12	0.12	0.12	0.16	0.09	0.09
10	0.16	0.16	0.09	0.12	0.12	0.12	0.16	0.09	0.09
11	0.14	0.14	0.21	0.19	0.19	0.19	0.45	0.21	0.21
12	0.45	0.45	0.52	0.49	0.49	0.49	0.14	0.21	0.21
13	0.16	0.16	0.09	0.12	0.12	0.12	0.16	0.09	0.09
d items	**0.20**	**0.18**	**0.14**	**0.16**	**0.16**	**0.16**	**0.20**	**0.13**	**0.14**
% items	**85%**	**92%**	**92%**	**92%**	**92%**	**92%**	**85%**	**100%**	**92%**
A scores	**0.69**	**0.69**	**0.74**	**0.72**	**0.72**	**0.72**	**0.69**	**0.74**	**0.74**

There are five ISPS underlined the Malaysian primary science curriculum. This study determined to verify the content of instrument applying rating scale items which match the indicators for measuring pupils ISPS competency using experts review. Although the Malaysian Examination Syndicate has introduced the schoolbased, hands-on PEKA to assess students' practical work, such assessment is still subjective in nature as it depends on a teacher's discernment, capability and acumen in assessing practical work based on the identified constructs of science process skills (Ong et al. 2015). As PEKA is mandatory, a kind of self response instrument could be counted as a supplementary to the practical work assessment to measure primary students' acquisition of science process skills. Hence, there is an urgency to develop and validate such measuring tool in order to lessen teachers burden.

Conclusion

This finding indicates that all the items were accepted to match the indicators of ISPS in terms of content validation. Fuzzy Delphi is an ideal method in obtaining experts approval. Questionnaire is an easy tool to be administrated upon many specialists which are barely to meet due to various restrictions. All the items-indicators designed for the ISPS instrument achieved all underlined condition using FDM by the experts' viewer. There are many techniques to assess expert review for content validation but this study chooses to apply FDM. Now, the instrument is ready to be disseminated to the respondents and enter the next stage of construct validation. Finally, the criterion validation will take place. All these phases complete the instrument development process. All for one which started with content validation by FDM.

Corresponding Author

Ellyza Karim, PhD. candidate, UKM Bangi, Malaysia, ellykarim@siswa.ukm.my

Acknowledgements

The authors convey their gratitude to the science educators involved from IPG Teknik, IPG Raja Melewar, IPG Ilmu Khas, CDC, UKM, UPM, UNITAR, SK Sendayan and SMS Seri Puteri in providing the relevant suggestions for conducting this research study and to Dr. Mohd Ridhuan Mohd Jamil (Politeknik Nilai) for his valuable review on FDM.

References

Abu Hassan K., & Rohana H. (2003). Tahap Penguasaan Kemahiran Proses Sains dan Hubungannya dengan Pencapaian Kimia di kalangan Pelajar Tingkatan Empat Daerah Johor Bahru. Retrieved from http://eprints.utm.my/2345/

Adler, M. & Ziglio, E. (1996). *Gazing into the oracle: the Delphi method and its application to social policy and public health.* London: Jessica Kingsley Publishers.

Burns, J. C., Okey, J. R. & Wise, K. C. (1985). Development of an Integrated Process Skill Test: TIPS II. *Journal of Research in Science Teaching,* 22(2), 169-177.

Beaumont-Walters, Y., & Soyibo, K. (2001). An Analysis of High School Students' Performance on Five Integrated Science Process Skills. *Research in Science & Technological Education*, 19(2). Retrieved from http://dx.doi.org/10.1080/ 02635140120087687.

Chang, P.-L., Hsu, C.-W., & Chang, P.-C. (2011). Fuzzy Delphi Method for Evaluating Hydrogen Production Technologies. *International Journal of Hydrogen Energy*, *36*(21), 14172–14179. doi:10.1016/j.ijhydene.2011.05.045

Cheng C. H., & Lin Y. (2002). Evaluating the Best Main Battle Tank using Fuzzy Decision Theory with Linguistic Criteria Evaluation. *European Journal of Operational Research, 142*, 174-186.

Chiappetta, E. L., & Koballa, T. R. (2006). *Science instruction in the middle and secondary schools: Developing fundamental knowledge and skills*. San Francisco: Pearson Merril Prentice Hall.

Chu, H. C., & Hwang, G. J. (2008). A Delphi-Based Approach to Developing Expert Systems with the Cooperation of Multiple Experts. *Expert Systems with Applications*, *34*, 2826–2840. doi:10.1016/j.eswa.2007.05.034

Curriculum Development Centre. (2013). *Dokumen standard kurikulum dan pentaksiran sains tahun empat.* Putrajaya: MOE.

Dillashaw, F. G., & Okey, J. R. (1980). Test of Integrated Science Process Skills for Secondary Students. *Science Education.* 64, 601-608.

Edy Hafizan M. S., & Lilia H. (2010). Development and Validation of a Test of Integrated Science Process Skills*. Procedia Social and Behavioral Sciences, 9*, 142-146. doi:10.1016/j.sbspro.2010.12.127

Harlen, W., & Elstgeest, J. (1992). *UNESCO sourcebook for science in the primary school: A workshop approach to teacher education.* Paris: UNESCO Publishing. Retrieved from http://unesdoc.unesco.org

Harlen, W. (2006). *Teaching, learning and assessing science 5-12*. London: SAGE Publications Ltd.

Jones, H., & Twiss B. L. (1978). *Forecasting technology for planning decisions.* New York: Macmillan.

Kazeni, M. M. M. (2005). Development and validation of a test of integrated science process skills for the further education and training learners. Master dissertation, Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa.

Krosnick, J. A., & Presser, S. (2009). Question and questionnaire design. *Handbook of Survey Research*, *2*(3), 263-314.

Ludeman, R. R. (1975). Development of the science processes test. Paper work presented at Annual Meeting of National Association for Research in Science Teaching, Mac, Los Angeles.

Mat Rasit I. (2014). Kajian Keberkesanan Program Pentaksiran Kerja Amali Sains (PEKA): Satu Penilaian di Sekolah Rendah. *Jurnal Pendidikan Malaysia 39*(2), 83-93.

Nazirah M. A., Abdullah Hisam O., Shuib R., Rodzah Y., Siti Zainon M., Tuan Mohammad T. Y., Wan Muhammad Aizat W. A., Mohd Farid Al Azmi I., & Mohd Naszrie R. (2015). Fuzzy Delphi for marine space stakeholder framework development: An analytical literature review. Paper work presented at The World Cadastre Summit, Congress & Exhibition, 20 –25 April, Istanbul, Turkey.

Ong, E. T., Wong, Y. T., Sopia M. Y., Sadiah B., Asmayati Y., & Zahid M. S. (2012). Malaysian Based Science Process Skills Inventory: Development, Validation and Utilisation. *CREAM – Current Research in Malaysia*. 1(1), 125-149.

Ong, E. T., & Mohd. Al-Junaidi M. (2013). Pembinaan dan Penentusahan Instrumen Kemahiran Proses Sains untuk Sekolah Menengah. *Jurnal Teknologi (Social Sciences).* 66(1), 7–20.

Ong, E. T., Norjuhana M., Siti Eshah M., Sabri M. S., Nik Azmah N. Y., & Koon, P. Y. (2015). Basic Science Process Skills Test for Primary Schools: Item Development and Validation**.** *Jurnal Pendidikan Sains & Matematik Malaysia. 5*(1).

Oppenheim, A. N. (2009). *Questionnaire design, interviewing and attitude measurement. New edition.* London: Continuum.

Padilla, M. J. (1990). The Science Process Skills. *Research Matters - to the Science Teacher, 9004.* Retrieved from https://www.narst.org/publications/research/skill.cfm

Rezba, R.J., Sprague, C., Fiel, R.L., & Funk, H.J. (1995). *Learning and assessing science process skills*. 3rd ed. Iowa: Kendall/Hunt.

Shanteau, J., Weiss, D. J., Thomas, R. P., & Pounds, J. C. (2002). Performance-based assessment of expertise: How to decide if someone is an expert or not. *European Journal of Operational Research*, 136, 253-263.

Schuman, H. (1972). Two Sources of Anti-War Sentiment in America. *American Journal of Sociology*, 78, 513-536. Retrieved from https://deepblue.lib.umich.edu/handle/ 2027.42/ 91773

Sheeba, M. N. (2013). An Anatomy of Science Process Skills in The Light of the Challenges to Realize Science Instruction Leading to Global Excellence in Education. *Educationia Confab, 4*(2), 108-123. Retrieved from http://wwwconfabjournals.com/confab journals/ images/6520138281213.pdf

Smith, K. A., & Welliver, P. W. (1990). The Development of a Science Process Assessment for Fouth-Grade Students*. Journal of Research in Science Teaching*. *27*(8), 727-738.

Tang, C.W., & Wu, C.T. (2010). Obtaining a Picture of Undergraduate Education Quality: A Voice From Inside the University. *Higher Education* (60), 269-286.

Temiz, B. K., Tasar, M. F., & Tan, M. (2006). Development and Validation of a Multiple Format Test of Science Process Skills. *International Education Journal, 7*(7), 1007-1027.

Yeoh P. C., & Gan C. M. (2004). Emphases of Malaysian primary science curriculum. In. Yap K. C., Goh N. K., Toh K. A., & Bak H. K. *Teaching primary science*, Jurong: Pearson Prentice Hall.