SciEd

SEAQIS Journal of Science Education

vol. 3 / no. 1 / June 2023
E-ISSN 2964-7533
P-ISSN 2987-8101

DOI prefix: 10.58249 by Crossref

www.journal.qitepinscience.org

ISSN 2987-8101
9 772987 810002

ISSN 2964-7533
9 772964 753001

SciEd

SEAQIS Journal of Science Education

Director's Message

Dear readers,

Welcome back to the 3rd volume of SEAQIS Journal of Science Education (SciEd). SciEd is one of the platforms for science teachers and education personnel to display their works and innovation through academic writing.

This issue will provide you with various research by authors from all across Southeast Asia that can enrich your knowledge in science education, such as experiment-based learning and how factors outside the classroom can influence academic performance.

Hopefully, all the articles published in this journal have a significant impact on the science education world. Thank you and happy reading!

Dr Indrawati
Director

From the Editor-in-Chief

Welcome to the 3rd volume of SciEd. First and foremost, we would like to express our heartfelt gratitude to all the authors, the Editorial Board, the designer, the Publishing Office Staff, and everyone who has contributed to this publication. Your dedication and hard work have made this publication possible.

As with any endeavour, it is possible that errors and mistakes might have slipped through the cracks in this issue. Therefore, we encourage critics, comments, and suggestions from our readers, as they are invaluable in improving the quality of our future volumes. Your feedback plays a crucial role in our continuous efforts to enhance the content and presentation of SciEd.

We also take this opportunity to invite you to collaborate with us by submitting your best articles for consideration in the upcoming volumes. Your contributions will help us further broaden the readers' knowledge and understanding of Science. Together, we can create a vibrant and informative platform for scientific discourse.

Thank you for your support and encouragement. Together, let us strive for the advancement and enrichment of science education.

Sincerely,

Dr Elly Herliani
Editor-in-Chief

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The Desk

SEAQIS Journal of Science Education (SciEd)

Volume 3 | No 1 | June 2023
E-ISSN 2964-7533
P-ISSN 2987-8101

SEAQIS Journal of Science Education (SciEd), The Southeast Asian Journal of Science Education, is a scientific publication of SEAMEO QITEP in Science published once a year. It contains scientific research articles in Science Education and a review article. A guide for the author can be found on the website.

SciEd Editorial Office
SEAMEO QITEP in Science, Kompleks Balai Besar Guru Penggerak Provinsi Jawa Barat,
Gedung B, Jl. Dr. Cipto No.9, Bandung, West Java 40171, Indonesia
E-mail: seaqis.journal@seameo.id | Home page: journal.qitepinscience.org

Cover:
Art of Photography about science learning daily at home

2023
SciEd
SEAQIS Journal of Science Education
SEAQIS Journal of Science Education (SciEd)
E-ISSN: 2964-7533
Vol: 3, No: 1, PP:1-13
www.journal.qitepinscience.org
Research Paper
Open Access

Development and Validation of Most Essential Learning Competency- Based Workbook in General Physics 1 for Senior High School

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Abstract

One of the best things a teacher can do to help students achieve a quality learning process is to create and validate instructional materials. With this, a descriptive-developmental research design following 3phase namely development, implementation, and evaluation was utilised to develop the most essential learning competency-based workbook in General Physics 1 for Senior High School and validate it through a rating scale distributed to groups of respondents. The developed MELC-based workbook in General Physics 1 was based on the 85 most essential learning competencies for the whole semester using the six components namely topics, specific objectives, key concepts, directions, activities, and reflections. The three groups of respondents were the purposely selected group of experts; all teachers handling General Physics 1 in the Division of Northern Samar and all grade 12 STEM students enrolled in the STEM strand at the Bobon School for Philippine Craftsmen on the first semester of SY 2021-2022. Moreover, mean and standard deviation were used to measure the validity of the workbook. The study disclosed that the respondents evaluated the workbook to be both content and face-valid as proved in their questionnaire labelled as "agree" in the indicators. Furthermore, the results showed that the MELC-based workbook has met the standard and could be used as a learning material. Therefore, it was recommended by the researchers that the said workbook be used as learning material for the said subject matter. Further study on the effectiveness of the said workbook must be conducted with consideration of some factors.

Keywords: General Physics Workbook, instructional material

Introduction

The quality of education is the primary concern of every teacher to all students. As a result, teachers constantly create and put into practice new strategies and techniques to aid students in achieving mastery levels in each learning competency. In this regard, one of the best things a teacher can do to help students to achieve a quality learning process is to create and validate learning resources or instructional materials, such as a workbook. During the teaching and learning process, the utilisation of instructional materials is crucial. Thus, the use of educational materials by teachers would substantially aid them in explaining the learning process to students in particular. Additionally, a learning tool like a workbook incorporates learning techniques that assist pupils to develop certain skills in addition to being a compilation of tasks (Adora, 2014; Adora, 2019; Rongayan, Jr. & Dollete, 2019). The students will also be able to build self-discipline, study habits, and initiative through the usage of learning resources which are the best practices to help them to be prepared for higher education (Li, 2016).

Needless to say, it is essential to use instructional resources like workbooks, modules, visual aids, and others for teaching and learning since these educational resources encourage and provide a concrete learning experience. Teachers, therefore, should continue to develop teaching resources like workbooks as suggested by Jean Piaget's Cognitive Learning Development Theory and Howard Gardner's Multiple Intelligence Theory (Zhuo & Brown, 2015).

Furthermore, the study on converting traditional classrooms for instruction into student-based classrooms using multimedia-mediated learning modules has shown that using multimedia-mediated learning modules, or simply using self-paced learning materials, is one of the contemporary and timely approaches best suited to student-based learning because it encourages students to take initiative to continue learning at their own pace and in their own space. In this way, the pupil could cultivate a sense of accountability and strive to learn more and perform better (Li, 2016).

On the other hand, many secondary school students, as well as some adults pursuing academic degrees, find physics to be a challenging subject (Ekici, 2016). This is due, partially, to the fact that physics is a science that necessitates mathematics. This suggests that a stronger foundation in mathematics is required if one wants to be proficient or achieve mastery of physics. However, the results of 2019 Trends in International Mathematics and Science Study (TIMSS) by the International Association for the Evaluation of Educational Achievement (IEA) for the Philippines is problematic (Mullis *et al.*, 2020). The Philippines set a "new record" in the Programme for International Student Assessment (PISA), ranking second to last in terms of both mathematics and scientific literacy (Bernardo, 2020). Consequently, a number of problems, such as lack of teaching resources, inadequate teacher training, and lack of facilities to foster a scientific culture among Filipino students, are blamed for the low performance in science (Jalmasco, 2014; Rabino, 2014). Along these lines, the lack of instructional materials that are aligned with the target's most essential learning competencies, especially in the senior high school under the strand of Science, Technology, Engineering, and Mathematics (STEM) subjects, makes it challenging for teachers to teach some science concepts and principles (Rongayan & Dollete, 2019; Tugade, 2016). However, vis-à-vis this problem, the researchers also considered the difficulty of creating instructional materials that are relevant, research-based, and aligned to the target competencies in order to create a transition from a conventional to student-based teaching instruction in light of the aforementioned reason and the role of teachers as the primary implementers of the K–12 Curriculum.

Recently, the Department of Education (DepEd) Order No. 012, Series 2020, which addresses how to adapt the Basic Education Learning Continuity Plan (BE-LCP) for the 2020–2021 school year considering the COVID–19 Public Health Emergency, was presented as a guide and instruction for guaranteeing the quality of education when using various learning modalities. The utilisation of printed self-paced learning materials through modular distance learning is one of those learning methods. In a distance learning modality, the teacher and the pupils are geographically separated for the entirety of the learning process. Furthermore, DepEd has provided printed module materials for those remote regions with very low internet connectivity. The pandemic's humiliating experience has, however, raised questions about the effectiveness and timeliness of the delivery and replication of the self-paced learning materials from the various divisions. Since some of the activities are highly challenging for the students, there are also problems with the contextualisation of the content of the learning materials.

As a result, the researchers think it is essential to take into account the localised and contextualised approach in the self-paced learning materials for remote learning, in line with the aforementioned principle. The BE-LCP is required to rearrange the K–12 Curricula into the Most Essential Learning Competencies (MELC), according to DepEd Order No. 012, Series 2020 for School Year 2020–2021 only, the MELC must be delivered on a national level. Though, the DepEd does stress that the MELC experience will be used to update and enhance the curriculum. There are only eight learning competencies that are not included in the MELC of General Physics 1 for the STEM strand since they require implementation and are not applicable to modular remote learning.

With the onslaught of the COVID-19 pandemic and the introduction of modular instruction as one alternative mode of learning, it has become even more imperative to develop instructional materials by which students will have their own independent and self-paced learning. In addition, keeping in mind the vision and mission of the DepEd under the K-12 curriculum which is to help students, especially those who are enrolled in the STEM strand to attain betterment through quality education, the researchers then came up with a study that focused on the development and validation of a MELC-based workbook in General Physics 1 for senior high school students which used the Reigeluth's (1999) Instructional-Design Theory as the foundation for this research. The Instructional Design Theory provides precise instructions on how to aid in the growth and learning of learners. The aforementioned theory identified two critical aspects of instruction and methodology in learning. First, it was stressed that instructions should contain: (a) clear information, such as descriptions and examples of the objectives, the knowledge required, and the performance expected; (b) opportunities for learners to actively and reflectively engage in learning activities; and (c) the aforementioned activities must be rewarding and highly motivating. Second, the aforementioned theory also emphasised that approaches should be situational depending on the circumstances of the learning environment and the desired learning outcomes.

Specifically, it sought to answer the following questions: (1) What are the components of the MELC-based workbook in General Physics 1?, (2) What is the assessment of the group of experts on the MELC-based workbook in General Physics 1 for senior high school in terms of the content validity (topic, specific objectives, key concepts, directions, activities, and reflections) and face validity (language used, format and layout, and level of difficulty)?, (3) What is the assessment of the group of experts, teachers handling General Physics 1 and Grade 12 students on the face validity of MELC-based workbook in General Physics 1 in terms of the language used, format, and layout?, and (4) What is the assessment of the group of experts and teachers handling General Physics 1 on the face validity of MELC-based workbook in General Physics 1 in terms of the level of difficulty?

Methodology

The study utilised descriptive-developmental research design in developing and validating a MELC-based workbook in General Physics1 for senior high school. In developmental research, instructional products or processes are designed, developed, and evaluated (Adora, 2014; Adora, 2019; Rongayan, Jr. & Dollete, 2019). In conducting the study to forty-four (44) respondents, as appeared in Table 1, composed of experts in the field, teachers, and students, the researchers utilised an adapted rating scale (Adora, 2014) in gathering the needed data for the study in answering the problems posed in the study, particularly in terms of content validity and face validity. To ensure that the data to be collected would meet the criteria for valid interpretation and analysis in this study, the adapted rating scale was presented to the experts for content validation.

Table 1. *Frequency Distribution of the Respondents of the Study.*

Group of Respondents	f
Experts	5
Teachers handling General Physics	6
Grade 12 STEM students	33
Total	**44**

A purposive sampling was utilised in the first group of respondents, the group of experts. They were composed of five professors/teachers: three (3) with master's degree in Physics, an English Major and a psychometric expert. On the other hand, total enumeration was used in selecting the second group which were composed of six (6) senior high school teachers handling General Physics 1 in the Division of Northern Samar and the third group of respondents who were composed of 33 Grade 12 students enrolled in STEM strand at the Bobon School for Philippine Craftsmen on the first semester of SY 2021-2022. The entire study was conducted in selected schools in the Division of Northern Samar.

The researchers gathered the data in three phases. The first phase was the development of the MELC-based workbook in General Physics 1. In this phase, the researchers first identified the most essential learning competencies in General Physics 1 and then formulated activities that were deemed relevant to the identified most essential learning competencies set by the DepEd.

The second phase was the implementation phase where the researchers first secured permission from the authorities to conduct the study. The researchers also asked the consent from the author of the rating scale as an instrument to be used in this study. Since the instrument was an adaptation of a previous work and validation had been conducted already by the said author with a validity score of 0.996, the present instrument then no longer needed its own validation. To ensure that the data to be collected would meet the criteria for valid interpretation and analysis in this study, a rating scale was presented to the expert panel members for content validation. After their scrutiny and having found the rating scale used was valid, the researcher then prepared the final instrument. Then, the rating scale and the MELC-based workbook in General Physics 1 were distributed to the three groups of respondents simultaneously at their convenient time within the first semester of the school year 2021-2022. The researchers personally conducted the implementation of the study. The group of experts and the group of teachers handling General Physics 1 were given enough time to scrutinise the MELC-based workbook and rated it accordingly. On the other hand, the group of students used the workbook as a part of the instructional material in General Physics 1 for the first semester which was administered by the researchers and then the latter was given time to rate the said workbook. The researchers administered the workbook through online discussion and limited face-to-face discussion in accordance with the health and safety protocol.

The third phase, the evaluation, was on analysis and interpretation of data that were collected from the second phase. The assessment of the content validity and face validity was determined with the use of statistical treatment.

Results and Discussion

The result of the analysis served as the basis for drawing out appropriate conclusions and recommendations. Mean value and standard deviation were used to describe the content and face validity of the workbook in General Physics 1 in terms of its components: topics, specific objectives, key concepts, directions, activities, and reflection.

Table 2. *Components of the MELC-Based Workbook in General Physics 1.*

	Components	Description
1	Topics	These are logically arranged based on the sequence of the most essential learning competencies.
2	Specific Objectives	These are specified objectives based on the most essential learning competencies.
3	Key Concepts	These are brief descriptions of the concepts areas to help the students/users of the workbook to recall some important points in the topics.
4	Directions	These are to lead the students/users of the workbook in answering the learning activities.
5	Activities	These are to provide learning opportunities for the students/ users of the workbook for developing mathematical skills and higher-order thinking skills.
6	Reflection	These are questions given after every set of rotations to encourage the students/user of the workbook to have a depth- analysis of his/her learning experience with this workbook.

Table 2 shows the six (6) components of the developed MELC-based workbook in General Physics 1. These were the topics, specific objectives, key concepts, directions, activities, and reflections. The researcher decided to use these components in parallel to the study of Adora (2014) and DepEd Order no. 1 series 2021 which provides specifically the guidelines on the evaluation of self-learning modules, but not including reflection. Teachers and students are expected to supplement the workbook with other learning materials to understand better the science concepts (Rongayan, Jr. & Dollete, 2019) since the workbook is merely one instructional material that teachers and students may use to enhance their learning. It is beneficial to introduce basic information to an entire class with instructional materials, thereby eliminating the need to conduct hours of lecture discussion (Garcia, 2020).

Furthermore, there is an increasing demand for STEM instructional materials to prepare students for a technologically and scientifically advanced society (English & King, 2015). Consequently, Cruz (2014) suggested that validated worktexts are considered as qualified if they have the characteristics that will help students enhance their performance.

Assessment of Experts on the Content and Face Validity of MELC-based Workbook *Content Validity*.

The group of experts assessed the MELC-based workbook in General Physics 1 for senior high school in terms of content validity. This aspect is composed of six (6) components namely: topics, specific objectives, key concepts, directions, activities, and reflection.

Table 3. *Mean and Standard Deviation on Experts' Assessment of the Content Validity of the MELC-Based Workbook in General Physics 1 in terms of Topics, Specific Objectives and Key Concepts.*

Content Validity	M	DES	SD
Topics			
1. The topics are sequenced according to Most Essential Learning Competencies (MELC)	4.80	SA	0.45
2. The topics are carefully organised.	4.60	SA	0.89
3. The topics are well-constructed.	4.40	A	0.55
4. The topics are logically arranged.	4.40	A	0.89
5. The topics are time-bounded.	4.40	A	0.55
Average	**4.52**	**SA**	**0.67**
Specific Objectives			
1. The specific objectives are based on the target learning competencies.	4.60	SA	0.55
2. The specific objectives are clearly stated and easily understood.	4.40	A	0.89
3. The specific objectives are measurable.	4.40	A	0.89
4. The specific objectives are attainable within the specified time limit.	4.20	A	0.84

5. The specific objectives are result-oriented	4.40	A	0.55
Average	**4.40**	**A**	**0.74**
Key Concepts			
1. The key concepts give insights and ideas about what the activity is all about.	4.40	A	0.89
2. The key concepts provide a background of concepts and information about the topic to be solved.	4.00	A	1.41
3. The key concepts arouse the learner's interest in solving the exercises.	3.60	A	0.55
4. The key concepts attract the learner's attention.	3.80	A	0.45
5. The key concepts are simple and comprehensive.	3.80	A	1.64
Average	**3.92**	**A**	**0.99**

Table 3 shows the assessment of the experts on the content validity of the MELC-based workbook in terms of topics, specific objectives, and key concepts. The topics of the workbook in General Physics 1 have been rated with an average mean of 4.52, described as "agree" with a standard deviation of 0.67. This data implies that the experts strongly agreed that the topics included in the workbook were well constructed, time–bound, logically arranged, and sequenced according to the MELC as required by the DepEd. Furthermore, the table also revealed that the specific objectives of the said workbook were rated with an average mean of 4.40, described as "agree" with a standard deviation of 0.74. Meanwhile, the key concepts were rated an average mean of 3.92, described as "agree" with a standard deviation of 0.99. This indicates that the specific objectives have met the requirements stipulated in the MELC and were captured by the users of the workbook to be clear, attainable, measureable, and result-oriented. This result is in line with the idea of Agustin (2019) who stressed that in developing a worktext, it should essentially meet the level and needs of the students. In addition, it also adheres to the principle that each lesson's content should offer students the opportunity to achieve the lesson's objectives (Basilio & Sigua, 2022).

In the same way, the experts also agreed that the key concepts of the workbook were useful, insightful, and comprehensive to the learners, despite the ratings being a bit lower than the other components. It means that the workbook has not fully met the expectations in arousing the interest of the learners. Therefore, further improvement and revision are needed to increase a strongly agree rating.

Table 4. *Mean and Standard Deviation on Experts' Assessment of the Content Validity of the MELC-Based Workbook in General Physics 1 in terms of Directions, Activities, and Reflection.*

Content Validity	M	DES	SD
Directions			
1. The directions are simple and clear.	4.20	A	1.10
2. The directions are easy to follow.	4.40	A	0.89
3. The directions are properly sequenced.	4.00	A	1.00
4. The directions can be done independently.	4.20	A	0.84
5. The directions lead the learners to answer the activities.	4.40	A	0.55
Average	**4.24**	**A**	**0.87**
Activities (Learning Space/Application/Take a Challenge)			
1. The activities are relevant to the objectives.	4.20	A	0.45
2. The activities are adequate to develop learners' mathematical and scientific knowledge and skills	4.20	A	0.45
3. The activities are adjusted to the learner's abilities.	4.40	A	0.55
4. The activities are sufficient to determine the learner's mastery level.	4.20	A	0.45
5. The activities provide opportunities for the development/ enhancement of mathematical and higher-order thinking skills.	4.40	A	0.55
6. The activities arouse learners' interest making learning effective and enjoyable.	3.80	A	1.10
7. The activities are contextualised.	4.20	A	0.45

Average	**4.20**	**A**	**0.57**
Reflection			
1. Learning experiences are expressed through reflection.	4.60	SA	0.89
2. The reflection gives insights to the teacher if the learner needs remediation or enrichment.	4.60	SA	0.55
3. The reflection guide questions help the learners to reflect on or examine their learning experience.	4.20	A	1.10
4. The reflection encourages the learner to provide an in-depth analysis of the learning experience.	4.20	A	1.30
5. The reflection evaluates the relevance of the workbook.	4.60	SA	0.89
Average	**4.44**	**A**	**0.95**

As reflected in Table 4, the experts assessed the workbook in General Physics 1 with an average mean of 4.24, described as "agreed" with a standard deviation of 0.87 for directions; and an average mean of 4.20 described as "agreed" with a standard deviation of 0.57 for the activities, and an average mean of 4.44 described as "agreed" with a standard deviation of 0.95 for reflection.

The results imply that the directions of the workbook in General Physics 1 were helpful for the learners to answer the activities easily. In line with this, the experts also agreed that the activities of the workbook are relevant to the objectives. It sufficiently provides the learners with opportunities to develop their mathematical and scientific knowledge and skills as well as higher-order thinking skills. Accordingly, the workbook supports the notion of Shahat *et al.* (2013) that learners need an environment that encourages active learning, critical thinking, scientific inquiry, and problem-solving. Yang and Liu (2016) hypothesised that inquiry-based tasks are intended to guide teachers and students in doing inquiry-based teaching and learning. Thus, the quality of inquiry-based tasks is crucial.

However, one of its indicators, "*the activities arouse learner's interest making learning effective and enjoyable*" was rated lower than the others and with a greater standard deviation. This is also evident in the "key concepts" part and implies that the workbook failed to meet the expectations of the learners in terms of enhancing their motivation and interest in learning the subject. This provided an implication that the workbook, even though crafted based on the needs of the learners, cannot just be considered as a standalone learning material; without the supervision and guidance of the teachers since learners were not used to do the activities independently. It means that the activities in the workbook can be further improved to increase interest and motivation. Furthermore, learning can become more significant, enjoyable, meaningful, and interesting by using worktexts that contain clear information and directions (Agustin, 2019).

The assessment on the component "reflection" was perceived to assist learners in evaluating their needs and the relevance of the workbook to them through in-depth self-examination of the learning experience with the help of the guide questions. This is in line with the study of Xhaferi & Xhaferi (2017) which found that reflection journals assisted students with learning strategies and becoming more independent.

Table 5. *Mean and Standard Deviation on Experts' Assessment of the Face Validity of the MELC-Based Workbook in General Physics 1 in terms of Language Used, Format and Layout and Level of Difficulty.*

Face Validity	*M*	*DES*	*SD*
Language Used			
1. The workbook uses formal language.	5.00	SA	0.00
2. The workbook observes correct grammar.	4.00	A	0.71

3. The language is comprehensive in terms of vocabulary.	4.00	A	0.71
4. There is good clarity and ease of understanding in the language used.	4.20	A	0.45
5. There is a sufficient familiar vocabulary to ensure learning.	3.80	A	0.84
6. The scientific terms used are comprehensibly defined.	4.00	A	1.22
Average	**4.17**	**A**	**0.65**
Format and Layout			
1. The workbook is clear and simple.	4.40	A	0.89
2. The workbook provides concrete visual clues.	4.20	A	0.84
3. To avoid duplication, the workbook is arranged logically.	4.40	A	0.55
4. It has a well-organised layout that makes the whole self-instruction material appealing and understandable.	4.40	A	0.55
5. There are appropriate structures, styles, and formats for the target audience.	3.80	A	0.84
6. The font sise is readable enough for the learners.	4.40	A	0.55
7. The color scheme is appealing to the eye.	4.40	A	0.55
Average	**4.29**	**A**	**0.64**
Level of Difficulty			
1. Learning activities are designed to accommodate learners with varying attitudes and abilities.	4.00	A	0.71
2. There is a good fit between the activities and the subject matter.	4.20	A	1.30
3. The activities are interesting, relevant, and self-motivating to the learner.	4.40	A	0.55
4. The activities are contextualised to which the learners can relate.	4.00	A	0.71
5. Every instruction is simple to understand and follow through.	4.00	A	0.71
Average	**4.12**	**A**	**0.79**

As presented in Table 5, the experts rated the language used in the MELC-based workbook as "agree" with an average mean of 4.17 and a standard deviation of 0.65; format and layout with an average of 4.29 described as "agree" with a standard deviation of 0.64; and the level of difficulty with an average mean of 4.12 described also as "agree" with a standard deviation of 0.79.

This data revealed that the experts agreed that the language used in the MELC-based workbook was formal, observed correct grammar, easy to understand, and comprehensible in terms of vocabulary. One of the indicators of language used in which "the workbook uses the formal language" was perfectly rated with a mean value of 5.00 and a 0.00 standard deviation. This implies that the experts unanimously and strongly agreed that the language used in the MELC-based workbook is proper and suitable for the learners. The students learning of the subject matter is indeed influenced by the use of clear, visible images and language (Cajayon & Benavides, 2022).

Furthermore, the format and layout used in the MELC-based workbook were assessed to be simple, readable, comprehensible, well-organised, and appropriate to the level of the learners. All the indicators were described as "agree" by the experts. In congruence to this rating, the level of difficulty in the MELC-based workbook was also evaluated to be favorable on the part of the learners because the experts agreed that the activities in the said workbook were contextualised, relevant and suitable to the level of the learners and the instructions were clear and easy to follow. Also supporting this result is the Inan and Erkus (2017) report, which notes that worksheets can be delivered visually and textually, which goes beyond traditional classroom delivery methods.

The overall assessment of the experts on the validity of the MELC-based workbook in General Physics 1 in terms of content validity (M = 4.29; SD = 0.80) and face validity (M = 4.19; SD = 0.70) which

were both described as "agree".

The data imply that the MELC-based workbook in General Physics 1 has met the requirements both in content and face validity for the material to be considered an acceptable and valid workbook for the intended learners. The research on these findings was consistent with several other studies (Evangelista *et al.,* 2014; Ocampo *et* *al.,* 2015; Pastor *et al.,* 2015, Rongayan, Jr. & Dollete, 2019). However, it has not reached the optimum rating which is "strongly agree". Therefore, it can be inferred that there is still room for improvement and further enhancements through revisions of the said workbook. Subsequently, Cajayon and Benavides (2022) asserted that students will only value learning tools they can grasp and master.

The assessment of the Face Validity of MELC-based Workbook in General Physics 1 in terms of Language Used and Format and Layout by the Respondents

Table 6. *Mean and Standard Deviation on Experts' Assessment of the Face Validity of the MELC-Based Workbook in General Physics 1 in terms of Language Used, Format and Layout and Level of Difficulty.*

Face Validity	*Experts*			*Teachers*			*Students*			*Total*		
	M	**DES**	**SD**	**M**	**DES**	**SD**	**M**	**DES**	**SD**	**M**	**DES**	**SD**
Language Used	4.17	A	0.65	4.75	SA	0.40	4.52	SA	0.57	4.48	A	0.58
Format and Layout	4.29	A	0.64	4.83	SA	0.38	4.44	A	0.51	4.52	SA	0.57

Table 6 disclosed the assessment results on the face validity of the MELC-based workbook in terms of the language used and format and layout by the groups of experts, teachers handling General Physics 1 and Grade 12 STEM students. As gleaned from the table, the respondents rated with an average mean of 4.48 and standard deviation of 0.58 for the language used and with an average mean of 4.52 and standard deviation of 0.57 for format and layout. As a result, the language used was described as "agree" and the format and layout are described as "strongly agree." This data imply that the three groups of respondents believed that the MELC-based workbook in General Physics 1 has met the standards of a workbook in terms of the language used and format and layout. This further implies that the readers or users of the workbook have found the learning material to be appropriate in terms of the vocabulary applied in presenting the lessons, exercises, and other activities. In addition, they have also found the layout of the material to be suited and appropriate vis-à-vis the level of the readers.

Accordingly, the ratings of the teachers handling General Physics 1 on the language used and format and layout of the said workbook obtained the highest ratings, as revealed by their means of 4.75 and 4.83, with standard deviations of 0.40 and 0.38, respectively. Thus, all the indicators both in language and format and layout were described as "strongly agree". The ratings signify that the teachers are very much in favor of the MELC-based workbook in General Physics 1 being used as instructional material as far as these aspects were concerned. It can be inferred that the experts, teachers handling General Physics 1, as well as the students perceived that the MELC-based workbook was incorporated to contain suitable and appropriate language vis-à-vis the level of the target learners.

The assessment by the Expert Group and the Teachers Handling General Physics 1 on the Face Validity of the MELC-based Workbook in General Physics 1 in terms of the Level of Difficulty

The study further determined the level of difficulty of the MELC-based workbook as perceived by the expert group and teachers handling the General Physics 1 subject. Table 7 shows the results of the average mean and standard deviation of the face validity of the workbook in terms of the level of difficulty which is 4.39 described as "agree" and 0.73, respectively. This implies that the experts and the teachers perceived the level of difficulty in the MELC-based workbook to be acceptable and tolerable to the target level of learners. The results clearly indicate that the expert group and the teachers believed that the MELC-based workbook is appropriate and helpful to the learners. They were also convinced that the workbook is responsive concerning the need for learning material that is suitable based on the level of skills and knowledge of the learners. Thus, using the workbook, the learners may find the material not only understandable, but also, an appropriate resource to enhance their skills and knowledge in General Physics.

Table 7. *Mean and Standard Deviation on the Assessment of the Face Validity of the MELC-Based Workbook in General Physics in terms of Level of Difficulty by the Experts and Teachers.*

Face Validity	*Experts*			*Teachers*			*Total*		
	M	**DES**	**SD**	**M**	**DES**	**SD**	**M**	**DES**	**SD**
Level of Difficulty	4.12	A	0.79	4.67	SA	0.59	4.39	A	0.73

The study's findings are in agreement with Rongayan, Jr. and Dollete's (2019) study, which demonstrated that the physical science workbook designed for senior high school students was well-received and validated by experts. The study's results are also comparable to Auditor and Naval's (2014) study, which found the created modules to be acceptable for 10th-grade physics students. Moreover, the findings of the study align with previous research by Inocencio and Calimlim (2021) which recommended the use of their workbook by Grade 8 Science teachers to improve students' performance and scientific literacy. This is also in line with the idea that instructional materials can help teachers deliver lessons effectively and make learning more accessible to students (Isola, 2010). Abdu-Raheem (2014) also showed that instructional materials are useful in clarifying concepts and making subject matter understandable to students. The results are similar to the findings of Monding and Bunel (2021), who found that the worksheets were effective in teaching basic science concepts and appreciated by students, leading to an improvement in their performance. The results are also consistent with the study of Cajayon and Benavides (2022), which concluded that the learning activity sheets contributed to the development of soft skills, such as creativity, communication, teamwork, and responsibility. Additionally, the results match the findings of Catuday (2019), who found that the laboratory workbook was well-formatted, easily understandable, and met the evaluation standards set for its target audience.

Conclusion and Recommendations

The components of the developed MELC-based workbook in General Physics 1 for senior high school provided significant inputs for the development of the MELC-based workbook that is responsive to the requirements of the Department of Education, particularly on the subject. Generally, the content and face validity of the workbook have met the requirements necessary for the acceptability of the learning material from the users' point of view. However, results do not speak of high quality and outstanding output; and therefore, require further improvement and revision. The varying perceptions of the experts, teachers, and students clearly indicate that the workbook did not satisfy some aspects which the respondents hoped to have addressed. The teachers handling General Physics 1 are more lenient in rating the face validity of the MELC-based workbook, in terms of the language used and the layout compared to the expert group and the Grade 12 STEM students. The level of difficulty of the MELC-based workbook in General Physics 1 for senior high school is just appropriate vis-à-vis the level of learners. Nevertheless, since there were varying perceptions, the workbook has some gray areas and lapses that need to be reviewed further.

The MELC-based Workbook in General Physics 1 may be published and used by teachers as well as students at senior high schools offering STEM strand. The MELC-based workbook in General Physics 1 may be used as one of the instructional or supplementary materials in teaching General Physics 1 for senior high school students under STEM strand. The school, district, and school division offices may intensify the conduct of workshops and training on the development of contextualised workbooks or instructional materials even in other subject areas, especially in senior high school subjects. Areas needing improvement in the developed workbook may be subjected to further review or revision. Other studies may be conducted to determine which areas in the workbook have resulted in differed perceptions of the respondents. Furthermore, studies may be conducted by future researchers on the effectiveness of the MELC-based workbook in General Physics 1 for senior high school.

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2023
SEAQIS Journal of Science Education (SciEd)
E-ISSN: 2964-7533
Vol: 3, No: 1, PP 14-26
www.journal.qitepinscience.org
Research Paper Open Access

Home Environmental Factors and Science Anxiety Affecting Academic Performance of Pre-Service Science Teachers

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Abstract

This study aims to identify the significant relationship between the home environmental factors and science anxiety affecting the academic performance of all pre-service science education students at the University of Mindanao. The data for this study came from 124 respondents who participated in completing the survey and was collected using a descriptive correlation design. The researchers used a random sampling technique to select the respondents. Using mean and Pearson r analysis, a significant relationship between home environmental factors and science anxiety affecting the academic performance of pre-service science teachers was revealed. The study found that parents' socioeconomic status and students' attitude resulted in a high mean and reached a high descriptive level. In contrast, parental involvement reached a low descriptive level. Science Anxiety with an indicator of science content showed low anxiety levels. The result revealed no significant relationship between the variables affecting the academic performance of pre-service science teachers. This study advocates the various effects of dealing with anxiety concerning the factors from home environment and academic performance experienced by the learners. Giving guidance and support that will provide students with interest and motivation may be considered.

Keywords: science anxiety, home environmental factors, academic performance, Philippines.

Introduction

Anxiety is a feeling of unease a human can feel when stressed and nervous. It obstructs the normal thinking process of an individual and causes a threat to their self-esteem and well-being (Ahmad & Ajmal, 2019). The development and progression of an individual highly affect their level of academic performance as a student. Through the years, the concern about home environmental factors and science anxiety has been apparent in our society. In the context of science, anxiety might involve the student's emotion and behaviour, which affects their educational background, strategies, limitations, enthusiasm, and gender (Ali, 2015). For science major students at the University of Mindanao, this challenge becomes critical to understand anxiety concerning science.

The home environment is the most notable institution for the existence and continuation of human life and the development of numerous personality traits (Mimrot, 2016). Moreover, Evans (2020) asserts that in regard to child development in Bronfenbrenner's ecological systems theory, a simple home and school environment, complicated societal ideals, rules, and practices all play a role in the intricate system of interactions that make up a child's development. Dealing with anxiety is an emotional process that we need to survive in our daily life. Nowadays, the percentage of students' anxiety is increasing in our new normal educational system. The anxiety brought by the subjects, particularly science, brings fear and disturbance among the students in schools, colleges, and universities. Although there are exceptionally excelling students in the mentioned subject, it cannot be repudiated that they are facing hardship in those subjects (Sanstad, 2018). Therefore, there is a need to conduct a study. The centre of this study is to measure the home environmental factors, anxiety among the students, and how to deal with them due to face-to-face classes while most students engage in online classes.

The independent variable (IV) indicates that home environmental factors affect academic performance. It represents the following three indicators: parental involvement, socioeconomic status, and attitudes of the students. First, parental involvement asserted by Naite (2021) affects the active involvement in their children's education. It may influence their growth, behaviour, and performance in academics from early to adulthood years of education. In addition, the socioeconomic status of a student's family or parents significantly affects academic success. The socioeconomic position of parents is a significant element that influences adolescents' academic achievement. Socioeconomic status specifies the combination of education, income, and profession. When a family exasperates poverty, the results may influence parenting and cause stress towards the children, affecting their emotional intelligence. The financial inadequacy of the parents makes the children feel inferior, which inhibits them from engaging with others and increases their daily stress (Chitra, 2020).

As Bhat et al., (2016) stated, parents' socioeconomic status influences academic performance and allows children from low socioeconomic backgrounds to compete with their high socioeconomic peers in the same academic environment. The parents' education levels can influence the value they have on education, which can influence a child's educational success, and further, be independent of income (Gobena, 2018). Afterward, the students' attitudes influence their decisions and achievements from various sources. The relevant criteria for evaluating academic success are their studying habits and attitudes. The negative and positive attitudes in physics significantly impact learning outcomes in physics and science, giving students a pessimistic approach towards learning, and making the learning process more complex now and in the future (Astalini et al., 2018).

On the other hand, the dependent variable (DV) indicates science anxiety, a debilitating cognition of science learning and negative emotion before and during science learning (Megreya et al., 2021). A similar study by Sanstad (2018) added that science anxiety is a specific field that drives emotions to constant dilemmas. Furthermore, Molin (2018) indicates anxiety in science is prevalent in exploration and science-related situations. Science content as an indicator represents a hostile field triggering students' in-depth emotional and psychological states and multiple perspectives on various concepts that reflect on balancing the factors of science and life (Brownell et al., 2018).

A study by Okoedion et al., (2019) implies that students' academic performance suffers due to the lack of family support. The lack of support and aid from friends and family members can affect the student's academic performance, emotional irregularities, short attention span, and a lack of self-esteem. The study by Muhammad et al., (2021) concludes that the home environment has a considerable impact on the emotion and thought competency or incompetency of parents and guardians, which has either confirming or antagonistic impacts on the student.

Parental involvement as described by Boonk et al., (2018) proves that the following variables show promise in terms of their correlations with academic achievements such as home reading, parents' expectations of the student's academic achievement, discussion between parents and children about school, and support for their learning. The analysis of Otani (2019) stated that students' attitudes and goals mediate the relationships between parental participation and academic achievement. Socioeconomic status, typically defined as an individual or group's social class, was coined by Ovansa (2017). According to Das, Halder, and Mishra (2014), attitude is the belief that one has towards people and their surroundings. Their positive attitudes may influence students' academic achievement. Attitude shapes people's feelings, represented in their likes and dislikes. However, Verešová and Mala (2016) believe that students who do poorly in school have a negative attitude towards learning and that education and learning will not help them prosper.

Science continues to grow because of the advancement we have right now. Generally, anxiety is the common, broad, and vaguely mixed collection of different fears, making college students' education challenging (Sanstad, 2018). Enrolling in science courses is already a factor of students' anxiety since digesting science content can be challenging for students who have different abilities to analyse the problem. Brownell et al. (2018) added that the science field could picture a hostile environment, resulting in a higher level of anxiety in students that triggers their emotional and psychological state. In some cases, students feel anxious when they are not welcomed and are poorly treated (AlKandari, 2020).

According to a study by Bulic and Blazevic (2020), the setting affects students' duties, engaging the new norm of the educational system. Students perceive satisfaction in controlling the process. Students who lack motivation are those who quit upright, as opposed to those who develop motivation through the fulfilment of the process. Psychological factors affect the changing behaviours caused by COVID-19 such as physical activities, excessive phone usage, and isolation. College students who do online education are at a higher risk of developing mental health issues, social isolation, and less interaction with their social networks (Lischer et al., 2021). The researchers are determined to measure the relationship between home environmental factors and science anxiety indicators affecting students' academic performance. However, no academic studies have focused on addressing this issue, and previous studies measured different variables related to this study. Therefore, this is the research gap for which the researchers found the need to conduct the study.

Objectives of the Study

The primary purpose of our study is to measure the home environmental factors among the pre-service science teachers and their relationship in science anxiety affecting academic performance, specifically to answers the following questions:

1. What are the home environmental factors affecting the academic performance among pre-service science teachers? (s? (parental involvement, socioeconomic status of parents, and attitudes of the student)2. How does science anxiety influence the academic performance of pre-service science teachers based on science content?

3. Is there any significant relationship between home environmental factors and science anxiety affecting the academic performance of pre-service science teachers of the University of Mindanao?

Null Hypothesis

There is no significant relationship between the variables affecting academic performance, tested at a .05 level of significance.

Methodology

Participants

The respondents of this study are the students enrolled in the University of Mindanao, especially in the College of Teacher Education Department. The researchers chose Bachelor of Secondary Education Major in Science students as the participants of this research. During the data collection process through a survey-designed questionnaire prepared by the researcher, 124 students responded, which took 43 days starting from February 12 to March 26, 2022. Some respondents could not respond due to their hectic academic priorities and poor connectivity. The sample size of 124 was significant and statistically measurable.Delice (2018) stated that a correlational study design should not be less than 30. It ratified Roscoe's idea of determining the sample size greater than 30 and less than 500 were fit to any behavioural studies (Memon et al., 2020) with a confidence level of 95% and a marginal error of 5.62%.

In addition, researchers use a random sampling technique to select the respondents since they are the ones who may provide the applicable information to appraise the hypothesis of this study. As face-to-face engagement may be limited, respondents can be selected online. The strengths of random sampling include its simplicity of utilisation and precise interpretation (Depersio, 2021). Inclusion criteria are the key features of the target population that the investigators will use to answer their research questions. Typical inclusion criteria include the level of exposure to home environmental factors, level of science anxiety, and the correlation between home environmental factors and science anxiety. Standard exclusion criteria include personal characteristics of eligible individuals such as the name, age, gender, status of a student, and year level.

Materials/Instruments

The study applies Ngussa and Gundula's (2019) "The Effect of Home Environmental Factors on Students' Academic Achievement: A Case of Community Secondary Schools in Monduli District, Tanzania" and; "Science anxiety levels in Emirati student teachers" adapted from Dickson et al., (2017) to create a 36-item survey questionnaire in measuring the relationship between home environmental factors and science anxiety affecting academic performance among the Pre-service Science Teachers.

Home environmental factors as independent variables fall into three sub-categories: parental involvement, socioeconomic status, and the attitude of students. The survey consisted of (17) questions to assess the participants with six items each for parental involvement and attitude of the students; five items for socioeconomic status. The instrument used the Likert Scale and its corresponding interpretations. The range of mean and descriptive levels anchors were: very high (4.20 – 5.00), indicating that home environmental factors are always manifested; high (3.40 – 4.19), indicating that the home environmental factors are frequently manifested; moderate (2.60 – 3.39) indicating that the home environmental factors are sometimes manifested; low (1.80 – 2.59) indicating that the home environmental factors are seldom manifested; and very low (1.00 – 1.79) indicating that the home environmental factors are never manifested.

Meanwhile, Science Anxiety as a dependent variable has one indicator of science content consisting of (19) questions to assess the participants. The instrument used the Likert Scale and its corresponding interpretations. The range of mean and descriptive levels anchors was: very high (4.20 – 5.00), indicating that the anxiety level toward science is always manifested; high (3.40 – 4.19), indicating that the anxiety level toward science frequently manifested; moderate (2.60 – 3.39) indicating that the anxiety level toward science is sometimes manifested; low (1.80 – 2.59) indicating that the anxiety level toward science is seldom manifested; and very low (1.00 – 1.79) indicating that the anxiety level toward science is never manifested. The researchers used Google Forms for the study to collect data.

After the data gathering, the researcher collected it for tallying scores and applying the following statistical tool used in the investigation. The Cronbach Alpha reliability test of Home Environmental Factors shows .920, which indicates reliability between Science Anxiety with .974. The study found both variables to be reliable and accepted. According to Chetty and Datt (2015), Cronbach's alpha statistic is a standard tool that assesses the reliability of the questionnaires or instruments developed or appropriately adopted for research initiatives.

To correlate the relationship between the home environmental factors and science anxiety affecting academic performance, the following interpretations were used: very high positive (.90-1.00), high positive (.70-.90) correlation, moderately positive (.50-.70), low positive (.30-.50), and negligible (.00-.30) correlation. Those mentioned above distinguish the significant relationship between the variables.

Design and Procedure

This study used a quantitative method involves objective measurement and statistical and mathematical or numeral analysis. Data collection focused on surveys, questionnaires, statistics and measure variables, and pre-existing data (Pal, 2017). The advantage and strength of using a quantitative research method is the ability to collect statistical data to saves time and resources (Daniel, 2016).

This research is also designated as the correlational type, as Creswell (2012) stated that correlation analysis entails gathering data to describe and measure the degree of relationship between two or more variables. This research has two variables: Home Environmental Factors (IV) and Science Anxiety (DV) which affect academic performance.

The researchers gathered the data by following a step-by-step procedure. First, they made a request letter to validate the questionnaires for a proper survey. The researchers obtain the request letter once the validators have approved it. Second, after the questionnaires' validation and approval, they were submitted to the thesis adviser for revision and some modifications to the questions. Third, the researchers used time allocation to administer the questionnaires through Google Forms. Fourth, after the data was gathered, the researcher collected it for tallying scores and applying the statistical tool used in the investigation. In line with the study's aims, the responses to the questionnaire items were tailed and recorded accordingly. The statistical tools used in the interpretation of gathered data were Mean and Pearson's r. The mean determined the Home Environmental Factors and Science Anxiety of the respondents. Mean can be used to compare different data (Dudovskiy, 2015). Meanwhile, Pearson's r determined the significant relationship between home environmental factors (IV) and science anxiety (DV).

Result and Discussion

Level of Exposure to Home Environmental Factors

The mean score for the level of exposure to Home Environmental Factors is presented in Table 1, with an overall mean of 3.56. This mean score attributed to the highest rating given by the respondents, indicating that the students frequently displayed a level of exposure to Home Environmental Factors. The resulting mean score of indicators ranging from highest to lowest was calculated to derive the overall mean score.

Two indicators were classified as high, which signifies the parents' socioeconomic status. It had the highest mean of 4.08, indicating that the Home Environmental Factors are frequently manifested. It means that the socioeconomic status of parents affects their financial academic in terms of expenses. This study supports the idea of Chen et al., (2018) that there is a high and stable correlation between the parent's financial status and their children's academic achievement. Meanwhile, student attitude received also received a high mean of 3.64. It means that the student's attitude depends on how motivated the learner is. The results were in consonance with a previous study by

Mao et al., (2021) that enhancing students' positive attitude toward science could be conducive to learning in science. It impacts students to improve positive attitudes that may be beneficial to science learning.

On the other hand, Parental Involvement has a mean of 3.04, which indicates that environmental factors are seldom manifested. It means the involvement of the parents moderately affects the academic performance of the pre-service science teacher. This finding agrees with the study of Rasool et al., (2021) that parents' involvement in their children's education at home has a significant positive impact on their academic achievement by assisting them with homework, projects, and other school activities that affect their studies.

Level of Science Anxiety

Table 2 emphasizes the level of science anxiety that deals with the indicator science content. The result is a mean of 2.54 which falls under the low category, indicating that the anxiety level of pre-service science students toward science is seldom manifested. The pre-service science students are motivated to learn Science.

The learning in science content among pre-service science teachers shows low anxiety levels. In line with the findings of Avci (2017), as a result of research conducted on students' low level of science anxiety, they are influenced by their learning environment based on the country's educational system through integrating the education and changing world's advancement. Students' engagement in science is more actively motivated by learning than in another subject.

The level of science anxiety about the science content results in a mean of 2.54 with a descriptive level of "low." This result aligned with the study of Downing et al., (2020) which students experience mild anxiety due to active participation in science courses and opportunities to learn through self-learning and group learning. Based on the theory of Yerkes-Dodson Law, the relationship between the feeling of pressure to perform a task and viewing anxiety as either an achievement or failure emotion varies across the students and the intensity of stress they experience.

Table 1. *Level of Exposure to Home Environmental Factors.*

Indicators	Mean	SD	Descriptive Level
Parental Involvement	3.04	.97	Low
Socioeconomic Status of Parents	4.08	.85	High
Student Attitude	3.64	.81	High
Overall	**3.56**	**.64**	**High**

Table 2. *Level of Science Anxiety.*

Science Content	Mean	SD	Descriptive Level
1. I am afraid of science courses bringing down my overall GPA.	3.31	1.23	Moderate
2. I do not want to learn science if it is not mandatory.	2.30	1.10	Low
3. I am afraid of science exams more than any other exams.	3.06	1.24	Moderate

4. Thinking about learning new concepts, formulas, and definitions related to science makes me nervous.	2.87	1.26	Moderate
5. It is not necessary to learn science to be successful in my life (outside work).	2.05	1.16	Low
6. My mind goes blank in science exams, and I cannot think.	2.85	1.17	Moderate
7. I usually feel unhappy when learning science.	2.30	1.22	Low
8. It always makes me anxious that science is a compulsory course in the curriculum.	2.34	1.22	Low
9. Doing science activities in the classroom makes me uncomfortable.	2.42	1.23	Low
10. I feel like I am in a deep hole when solving science-related questions.	2.64	1.22	Moderate
11. I get stressed just when entering the classroom if the class is science.	2.38	1.17	Low
12. Learning science is not necessary to succeed in my career.	1.97	1.18	Low
13. I worry that the teacher will ask me questions in science class.	2.97	1.29	Moderate
14. I become nervous when I have to do science homework.	2.63	1.17	Moderate
15. I feel uncomfortable when I enter the science lab.	2.27	1.11	Low
16. I usually daydream in science class.	2.46	1.22	Low
17. I do not answer in science class even when I know the answer in case my friends make fun of me.	2.69	1.31	Moderate
18. I cannot learn science no matter how much I study.	2.35	1.20	Low
19. Everybody except me understands science.	2.41	1.24	Low
Overall	**2.54**	**0.96**	**Low**

Relationship between Home Environmental Factors and Science Anxiety

Table 3 displays study findings using the Pearson Product Moment Correlation Test. Parental involvement (r= .318, p<.05) and student's attitude (r= -.195, p<.05) are significantly related to science anxiety while socioeconomic status of parents and science anxiety is not significantly related (r= .025, p>.05). Home environmental factors are related to Science Anxiety (r=.110, p>.05), which means that there is no significant statistical difference. Therefore, the alternative hypothesis was not supported.

Among the three indicators, socioeconomic status relates to the highest result percentage based on the question specifying "I have access to basic needs at home (clothes, food & shelter)" that has a mean of 4.59, followed by "My parents support my academic needs" with a mean of 4.23. The findings revealed that the socioeconomic status of pre-service teachers at the University of Mindanao has low correlation to anxiety. It means that they are well supported financially in school, which leads to better academic performance; this was in line with the findings of Mishra (2021). Therefore, the revealed statistics goes in line with the null hypothesis. On the contrary, the student's attitudes toward science anxiety revealed a significant relationship in science anxiety. This finding has an overall mean of 3.64, rejecting the statistical decision affirmed by Besoyo and Tancinco (2016) that the attitude of the student in learning science and their anxiety level does not correlate.

Moreover, in line with the ideas of Özbuğutu (2021), it can be figured that students' scores on science anxiety and attitude show a significant relationship wherein moderate and hostile toward the science lesson. Parental involvement was also rejected based on the statistical decision in dealing with student anxiety. It provides the overall mean of 3.04 and determines the relationship of this indicator− science anxiety. This paper cannot comprehensively review parental involvement due to practical constraints. As proved by Qasem (2018), the involvement of parents actively supports and motivates a learner's academic performance. Previous research findings in Barger et al., (2019) has discussed different support dimensions such as schooling, homework context, and academic adjustment for student development.

Thus, the findings of this study have shown no significant relationship between home environmental factors and science anxiety affecting academic performance.

In general, the statistics for home environmental factors indicates an "accepted" outcome, interpreting "no significance" between the science anxiety of the pre-service science teachers of the University of Mindanao and factors relating to home environment. The home environmental factors overall resulted in a mean of 3.56, indicating a high level of exposure to students affecting their academic performance. This finding grounded bio-ecological system theory, as stated by Madison (2016), that parents' influence plays a bidirectional role in shaping the whole child with the security, resources, and cognitive and behavioural aspects but does not contribute to the child's anxiety in learning science courses.

Table 3. *Correlation between Home Environmental Factors and Science Anxiety.*

Variables	Science Anxiety		
	r-value	**p-value**	**Decision on H_o**
Parental Involvement	.318*	.000	Reject
Socioeconomic Status of Parents	.025	.783	Accept
Students’ Attitudes	-.195*	.030	Reject
Home Environmental Factors	**.110**	**.225**	**Accept**

*p < .05 is significant (two-tailed)

Conclusion

The study's findings conclude that the level of exposure to home environmental factors indicates a "high" overall and across all indicators: parental involvement, socioeconomic status of parents, and student attitude. The student's academic performance is highly influenced by parents' socioeconomic status and students’ attitudes. In contrast, parental involvement is occasionally involved in their child's school progress and performance. The home environmental factors go in line with Bronfenbrenner's theory, the Five Systems, the development of a child grow as they expand their environment and interact with people, starting from their parents and the status they lived off of. The student's attitude reflects how the child is moulded through their environment, sculpting their own values and visions. Therefore, the level of science anxiety is low, particularly in science content. Science anxiety has low results, which did not affect students' academic performance in school, but they were highly motivated to learn the science content. Moreover, pre-service science teachers in the University of Mindanao have no significant relationship between home environmental factors and science anxiety. It also contradicts from the findings of the study conducted by Ozbugutu (2021), where there was a significant relationship between science anxiety and environmental sub-dimension. It modifies that we cannot control the influences of each variable as a concluding result.

This study's result strengthens the students' progression in managing themselves in engaging home environmental factors and science anxiety. Since the study showed no significant relationship between home environmental factors and science anxiety, it magnifies that it influences the factors from home environmental in anxiety connecting the student's academic performance. In practice, the study also highlighted that during the pandemic, even though the educational system is online-blended learning, it deals with standard navigation from the learners, which are also the factors from the home environment and science anxiety showing limitations to a new environment of learning. How learners manage themselves for this new educational system is the general question of the stakeholders' role in the educational system, that is why researchers conducted this study to examine how this affects the pre-service science teachers.

Recommendation

This study advocates the learners' various effects of dealing with anxiety resulting from the factors of home environment and academic performance and if there would be a significant relationship between the variables or none. Perhaps, there are more possible factors that may affect the academic performance of pre-service science teachers. It needs to consider giving guidance and support that will provide interest and motivation to students. Continuing to provide psychological tests, counselling, daily monitoring from the parents and school administration, and peer counselling interaction between students. In addition, factors including teaching approaches, learning materials and instruments, performance and development, educational standards, peer pressure, and self-distraction variables should be considered to be tested.

This study is beneficial in providing awareness to students, faculties, and stakeholders of possible circumstances. In some cases, if a pandemic were to happen again, it may occur with limited interaction between students, teachers, and the process of learning. It contributes to the advantages of students, where they can cope with limitations as individuals and can motivate through the setting of learning. Mastering a specific field is the cornerstone in tackling specificities in line with the variables that are not yet covered and discussed in the following inquiry. The result of the research may serve as a basis for the subsequent study in identifying the home environmental factors and science anxiety that may be a result of incompetence of pre-service science teachers. Moreover, these two variables will be a great deal to learn how to teach and master science context and other fields.

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2023
SciEd
SEAQIS Journal of Science Education (SciEd)
E-ISSN: 2964-7533
Vol: 3, No: 1, PP 27-34
www.journal.qitepinscience.org
Research Paper
Open Access

Master Teachers and Department Heads AS Science Instructional Leaders: A Case Study on Their Role as Instructional Programme Managers

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Abstract

As instructional leaders, master teachers and department heads are equally important in harnessing commendable scholastic performance for both teachers and students. This paper explored the case on how science master teachers and department heads practice on science instructional leadership, thereby creating an in-depth description and analysis of their ideals and realities. An electronic open-ended survey questionnaire and semi-structured individual interviews with six participants were used to collect data. Findings revealed that the practices of master teachers and department heads on coordinating the science curriculum dimension include fostering professional development among science teachers, providing technical assistance to science teachers, and organizing programs, projects and activities related to science**.** Meanwhile, ensuring instructional competence of science teachers and performing classroom observation as prescribed by Department of Education are their practices under supervising and evaluating science instructions. For monitoring student's progress, participants' practices include focusing diverse assessment strategies towards science process skills. This study also unveiled that the participants faced dilemma in their role as instructional leaders because of additional tasks aside from the prescribed duties and responsibilities of science master teachers and department heads expected from them. Moreover, documentary analysis disclosed that the instructional leadership of science master teachers and department heads significantly influences the school performance. Further study on the relationship between instructional competence of school leaders to its performance indicators is warranted.

Keywords: science instructional leaders, managing instructional programmes

Introduction

Societal dynamics necessitate adaptive measures in promoting knowledge, skills and applicability. Thus, in order to provide society with adaptable and life-long learners, the education sectors must catch up to these demands. One profound consideration in realizing these demands is the thorough and functional practice of instructional leadership across levels of the educational arena. Congruently, refining and cultivating instructional processes does not only revolve through the leadership of the school principals but also the distributed efforts across designated personnel such as department heads and master teachers (Spillane & Diamond, 2007; Spillane, Diamond, & Jita, 2003). Master teachers' and department heads' instructional leadership practices are far more relevant than those of the principals. Thus, examining these practices can provide input to the improvement of the way education is delivered to its important clientele – the students.

True enough, a number of authors (Dania & Andriani, 2021; Day, *et al.,* 2016; Hallinger & Heck, 2010; Hallinger &

Hosseingholizadeh, 2019; Harris, *et al.*, 2019; Manaseh, 2016; Moeketsane, *et al.,* 2021; Munna, 2021; Spaull, 2013; Spillane & Zuberi, 2009; and Wood & Olivier, 2008) highlighted that instructional leadership is important, suitable, and strongly felt to have promoted the improvement the school's and student's performance. Additionally, Weller (2001) suggested that master teachers and department heads are in a good position to promote instructional advancement due to their constant interaction with teachers and because of their instructional expertise.

However, to reinforce the instructional leadership skills and competency of the master teachers in the Division of Biliran, a development plan must be created (Laude, *et al.,* 2018). Manaseh (2016) argued that programs aimed at enhancing school leaders' capacities should put a particular emphasis on introducing them to the instructional leadership model and preparing them to supervise instructional modifications that would improve all students' levels of learning. Furthermore, follow-up research concentrating on teachers' instructional leadership should also be conducted to evaluate the impact of the inputs, according to the study Malitic (2020).

Munna (2021) emphasized that although the field of instructional leadership has been treated seriously, there is hardly any academic literature and no suitable guidance for carrying out the function of science instructional leadership. In order to strengthen instructional leadership in schools even when senior administrators are not present and to get subject leaders ready for success as senior managers in the future, Moeketsane, *et al.* (2021) recommended that subject leaders be completely integrated into instructional leadership programs. In conjunction with, since science instructional leaders are expected to provide administrative support to the program with attention for science laboratory activities in addition to the typical pedagogy, assessment, and curriculum improvement on the components of science, they may provide extra obstacles and challenges. Other than this, the high-stake assessments such as the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) results revealed disappointing results (Raya, 2021). Another issue is the frustrating results of the national achievement test for science. The instructional leadership practices used by department heads and master teachers in science may be accountable for these shortcomings and predicaments.

Thus, it is important to study master teachers' and department heads' practices in order to prepare them to carry out their responsibilities and functions, given the significant role they play in achieving the educational system's goals. Furthermore, despite the plethora of literature on instructional leadership, there are only few studies that highlight the science instructional leadership practices and challenges encountered by science instructional leaders in basic education within the realities in the Philippine schools. As a matter of fact, in the Philippines, the principals of the basic education schools are the main subjects of the most studies on instructional leadership (Arrieta *et al.*, 2020; Basañes, 2020; Bush *et al.*, 2016; Cahapay, 2022; Gamata, 2021; Laude *et al.,* 2018; Lincuna & Caingcoy, 2020; Malitic, 2020; Mendoza & Bautista, 2022; Pitpit, 2020; Sindhvad, 2009; Villa & Tulod, 2021) and it appears that science instructional leadership practices and roles of the master teachers and the department heads are unnoticed and snubbed. Peacock (2014) also argued that additional exploration and investigation is needed to specify the roles of Science Department Chairs such as Master Teachers and Head Teachers in science instructional leadership.

This study explored the practices of science master teachers and science department heads on Instructional Leaders using Hallinger and Murphy's (1985) Instructional Leadership Model specifically on "Managing Instructional Program" dimension as a conceptual lens. In this model, there are three dimensions in instructional leadership activities, namely determining school missions, managing instructional programmes, and creating school learning environments. The managing instructional programs dimension, which includes working with teachers on topics pertaining to curriculum and instruction, is the focus of this study. This dimension includes three sub-dimensions such as supervising and evaluating instruction, coordinating curriculum, and monitoring student progress. Providing teachers with instructional assistance, monitoring classroom instruction through a variety of casual classroom visits and matching the classroom objectives of teachers with those of the school are all parts of supervising and evaluating instruction. In coordinating curriculum, practices ensuring and guaranteeing the continuity of learning objectives for each grade that are directly connected to the material covered in class and in achievement exams are involved. Monitoring student progress includes giving teachers test results in a timely and helpful manner, talking with teachers about test results, and giving teachers interpretative analysis that succinctly summarizes the test data. However, as noticed, this model offers a general view of instructional leadership practices, hence, in this study, the context of science instructional leadership is specified.

Thus, the following research questions were asked in this study: (a) What are the practices of science master teachers and department heads in assuming their duties and responsibilities as instructional leaders in managing instructional programs?, (b) How are these practices different from the existing science instructional leadership standards on managing instructional programs?, and (c) Will these science instructional leadership practices on managing instructional programs affect the school performance?

Methodology

Research Design

This qualitative study employed a case study approach to explore and develop an in-depth description and analysis of the practices of science instructional leaders on managing instructional programs. According to Creswell (2013), a case study involves collecting detailed, comprehensive data over time from multiple sources of information about one or more cases. Through analysis of the data from multiple sources of information, in-depth understanding is provided through themes and issues identified by the researchers. Aside from the interviews with the key informants, we also evaluated relevant documents provided by the participants to provide a better and in-depth description of each case.

Participants and Sampling

For this study, we purposefully selected six participants from the public secondary schools in the Schools Division of the City of Meycauayan. Each participant currently holds a science instructional leadership role, serving as either a science master teacher or a science department head/chair for more than two years. They were asked to participate in this study and willingly agreed to partake in this endeavour as evidenced by their signed informed consent document.

Data Collection

We obtained approval and permission from the Schools Division Office of the City of Meycauayan to include science master teachers and department heads as study participants. Once we received their acceptance letter, we provided all participants with an informed consent document outlining the study's details and obtained their voluntary consent to participate. To gather the necessary data, we developed semi-structured interview questions and administered them to participants either face-to-face or via virtual conference platforms, depending on their preference. This interview format known as the "semi-structured interview" has become the most popular method for gathering qualitative data (DiCicco-Bloom & Crabtree, 2006). A semi-structured interview is a qualitative research technique that involves a prepared list of open-ended questions, but also allows for researchers to explore specific responses in greater depth. This approach enables the researchers to ask follow-up questions for clarification. In this study, the semi-structured interview questions were designed to elicit information on the participants' practices in enacting science instructional leadership roles, with a specific focus on managing instructional programmes.

Data Analysis

We utilised MS Excel to analyse the data collected and employed the thematic analysis framework proposed by Braun and Clarke (2006). This six-phase method provided a valuable framework for conducting our analysis. We read and reread the transcripts in the first stage to familiarise ourselves with the data. By creating initial codes, we arranged our data in a sensible and methodical manner. Third, when we looked over the codes, some of them clearly fitted together to generate preliminary themes. The basic themes that we had discovered were revised, improved, and developed in the following phases so that they are now well-defined and capable of supporting interpretations and conclusions.

Ethical Considerations

The researchers have taken steps to comply with data management protocols, beginning with the collection, storage, and analysis of data. Participants were fully informed and provided with guidance on their involvement in the study through the informed consent document, which they signed. The information gathered was treated with the utmost confidentiality, privacy and anonymity. The research participants received no remuneration or other financial benefits in exchange for taking part.

Conclusion and Recommendations

As science education continues to evolve and teachers encounter major overhauls on science curriculum, pedagogy, and assessment, science instructional leaders in the person of master teachers and department heads need to demonstrate science instructional and professional competence and support science teachers to adapt to societal dynamics.

With the paucity of research undertaken about the instructional leadership roles of science master teachers and department heads, this study has shown significant strides to account the efforts of instructional leaders in supervising and evaluating instruction, coordinating science curriculum, and monitoring student progress.

Findings of the study demonstrate practices that allow instructional leaders to manage the curriculum programs in schools by providing teachers with instructional assistance, monitoring classroom instruction, ensuring continuity of learning objectives, and managing student progress aligned to science process skills. Despite the ambiguity of the roles in the instructional leadership in schools, and even the additional ancillary tasks handed over to science master teachers and department heads, these practices are identified to provide significant contributions to the students' academic achievement, teacher's professional and teaching career growth, and the entire school's performance. By maintaining learning environments that have a favourable impact on teaching outcomes, effective science instructional leaderships roles are essential for engaging, empowering, and supporting high-quality teachers.

The findings present an initial insight into how instructional leadership practices of school science master teachers and department heads can be delved into and influence the school teaching outcomes. However, further study on the relationship between instructional competence of school leaders to its performance indicators is warranted.

Future research could include expanding the scope to reach more additional inputs on school instructional leadership practices. It is also worthwhile to investigate the other dimensions of the instructional leadership framework of Hallinger and Murphy (1985) to extend the understanding of other types of leadership practices and their prediction of performance indicators.

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2023
SEAQIS Journal of Science Education (SciEd)
E-ISSN: 2964-7533
Vol: 3, No: 1, PP 35-45
www.journal.qitepinscience.org
Research Paper
Open Access

Making Natural Acid-Base Indicators with a Science, Technology, Engineering, Mathematics (STEM) Approach to Chemistry Subjects During the Covid-19 Pandemic

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Abstract

This study focuses on the implementation of the STEM approach in chemistry subjects to develop natural acid-base indicators through contextual learning materials. The learning was conducted remotely using various digital services. To accomplish this, the experiment used the STEM approach with a Project-Based Learning model (STEM-PjBL), which was developed by Laboy-Rush and promoted by West Java Province Education Office in collaboration with SEAMEO QITEP in Science to develop natural acid-base indicators. The research findings were evaluated using qualitative descriptive methods to address the concerns that arose during the study. Data were collected through observations and student questionnaires regarding the implementation of the STEM approach in the acid-base indicator material. It was discovered that the STEM approach can be effectively employed in online learning during the Covid-19 pandemic. This study utilised plant parts obtained from the students' surrounding environment. However, before this experiment, students' knowledge about the nature of acid-base reactions in school snacks remain unknown.

Keywords: acid-base, natural indicator, online, STEM-PjBL

Introduction

SMAN 2 Padalarang is an eco-friendly school that has been honoured with the Adiwiyata School Awards in West Java Province. As a result, learning at school emphasised the integration of environmental awareness, issues related to the environment, and student hygiene. For instance, the type of snacks consumed by students in the school canteen is a significant consideration. While carbohydrates are necessary for proper digestion, students often opt for spicy and sour foods like *seblak* and *baslub (bakso kulub)* for breakfast. However, the consumption of these snacks can lead to gastritis due to increased stomach acid production caused by the presence of vinegar and chili sauce, which determine the acidic nature of the food. The behaviour of students in selecting snacks in the school canteen presents a contextual problem that can be addressed through chemistry education, specifically acid-base concepts.

Chemistry is a branch of natural science discipline that was initially taught as an independent subject in senior high school. Students are introduced to a "new language" starting with elemental symbols, which are then combined into chemical formulas until it becomes an equivalent chemical reaction equation. However, many students perceive chemistry as a difficult subject, in line with Wiyarsi, et al., as cited in Rahmawati, et al. (2021). This perception hinders their interest and comprehension of the subject. This marks the important role of teachers in bridging the gap and making chemistry more accessible to students.

The STEM approach can connect chemistry concepts to the daily life of students. In the context of acid-base materials, students are exposed to various types of school snacks (food and drink) that exhibit acidic or basic properties, which directly impact human digestive health, especially stomach acid levels. By providing students with this information, they can develop the ability to identify healthy food options. According to Tsupros, as cited in Herliani, et al. (2021), STEM education employs an interdisciplinary approach, integrating rigorous academic concepts with real-world lessons, enabling students to apply science, technology, engineering, and mathematics in contexts that connect school, community, work, and the global enterprise. This approach fosters the development of STEM literacy and equips students with the skills necessary to thrive in the new economy.

In early March 2020, an unexpected event occurred—the onset of the Covid-19 pandemic in Indonesia, which necessitated a shift to remote learning. Practical work and laboratory presentations that are fundamental to learning chemistry had to be conducted online from students' homes. Padalarang 2 Senior High School has had a Distance Learning Program since 2013, allowing both teachers and students to become familiar with the use of the Learning Management System (LMS) and other applications that support online learning activities. Therefore, this chemistry study was conducted online, combining both virtual and face-to-face features.

Based on the aforementioned factors, students are expected to develop a method for identifying the acidity and basicity of food and beverages (snacks in the school canteen). To achieve this, the experiment used the STEM-PjBL approach developed by Laboy-Rush and promoted by the West Java Province Education Office in collaboration with SEAMEO QITEP in Science to develop natural acid-base indicators. The use of natural acid-base indicators aligns with the vision and mission of SMAN 2 Padalarang as an eco-friendly school, as it offers a simpler and more accessible approach. Tseng, et al., as cited in Suwadarma, et al., (2020) demonstrated that STEM-PjBL enhances effectiveness and meaningful learning, as well as supports the career of students in the future by providing practical activities that solve real-world problems in the classroom.

There are several challenges in learning chemistry:

1. Students generally think that chemistry as a difficult, boring, and even annoying subject. Therefore, it is necessary to apply a learning model that improves students' understanding of concepts easily and pleasantly;
2. Students have limited knowledge regarding the identification of acids and bases contained in snacks. Thus, it is necessary to develop a simple and easy-to-use acid-base indicator;
3. Due to the Covid-19 pandemic, learning must be conducted online. Therefore, the usual face-to-face STEM-PjBL has been changed to online. It is necessary to understand how to effectively implement online learning and assess whether STEM-PjBL was able to be used to achieve basic competencies.

This research describes the benefits of applying the STEM-PjBL approach to develop natural acid-base indicators as a variety in learning chemistry. This variation in chemistry learning was expected to make students feel a different experience, preventing boredom during online learning amid the Covid-19 pandemic. Moreover, it is also expected to improve the quality of the chemistry learning process and foster the development of scientific, technological, mathematical, and engineering skills among students and teachers. This, in turn, equips the next generation of the Indonesian nation to compete in the current era of industrialisation 4.0.

Methodology

The study was conducted to develop natural acid-base indicators through the

STEM-PjBL learning model implementation. The syntax of the STEM-PjBL learning model includes reflection, research, discovery, application, and communication. This model was used by a group of 35 grade 11 students in the second academic year of 2019/2020 at SMAN 2 Padalarang. The research used questionnaires, student project reports, researchers' notes, and tests as instruments. The collected data consisted of descriptive information in the form of words, spoken statements, or pictures of the research subjects, which were analysed to draw conclusions using specific data analysis techniques (Creswell, as cited in Purwanto, et al, 2022). The research findings were evaluated using qualitative descriptive approaches to address the concerns that had been posed.

This study was conducted in a variety of tactics, including:

1. Implementing a learning model which is different from the commonly used approach. In this case, the STEM-PjBL approach was adopted to provide students with a more engaging and enjoyable learning experience in chemistry;
2. Using materials from the environment around students to develop acid-base indicators. By using the available materials, it is expected that students can easily grasp the chemical concepts related to acid-base indicators, as it closely related to their daily lives (contextual learning);
3. Learning chemistry online using various applications so that students are accustomed to using their devices positively during the learning process.

The data were collected through observation and student questionnaires regarding the use of the STEM-PjBL model in acid-base indicator material. The gathered information was then analysed using a simple computation approach based on sample percentages.

Research Discussion

The following are some of the implementations to solve the described problems.

1. Use of the STEM-PjBL Model

STEM-PjBL model was applied to teach acid-base indicator material with the aim of bringing chemical material closer to students' daily lives; and therefore, students can easily master chemical concepts. It starts with the problem of snacks that are usually consumed by students from the school canteen. Students often buy snacks without thinking of the health of their digestive system, especially their stomach. For example, in the morning, students buy boiled meatballs with red sauce (spicy) and pungent aroma of vinegar as their breakfast. In the concept of chemistry, the food consumed by these students is acidic. If the student has not had breakfast at their home and just consumes the snacks bought at school, it will cause their stomach acid to increase and hurt the stomach.

That issue is a stimulus for students to help them in understanding more the concept of acid base in chemistry. Through cooperation in groups with their classmates, students look for more comprehensive information on how to identify substances that are acidic and basic (acid-base indicator). Students then are guided to formulate and test the ideas in designing a study of acid-base indicators. Based on the environmental conditions of each group, this study is to obtain various types of plants that can be used as indicators of natural acid base. The STEM-PjBL learning model consists of five stages, as shown in Figure 1.

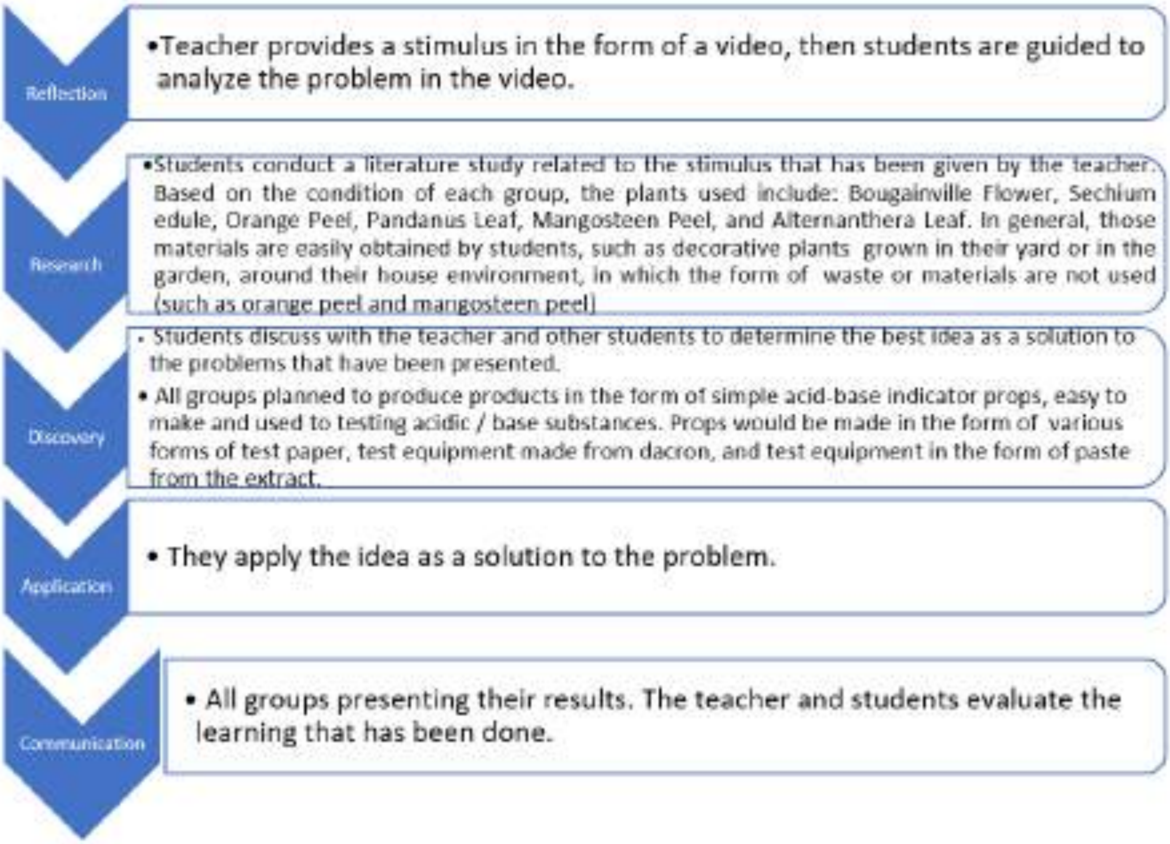

Figure 1. STEM-PjBL Learning Stages

Documentation of learning using the STEM-PjBL model on the acid base indicator material

Figure 2. Reflection and Research

Figure 3. Discovery

Figure 4. Application

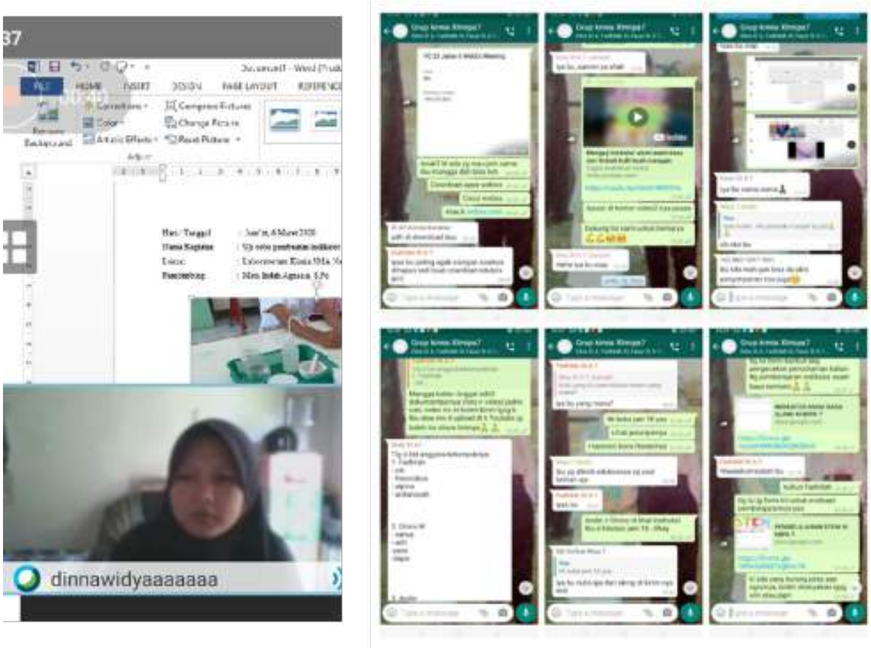

Figure 5. Communication with Webex and WhatsApp Application

Based on the questionnaires results, most of students were happy with the practice of the STEM-PjBL. It was their first experience studying chemistry with this learning model. Here are some of their responses.

Wish: I hope learning with STEM can be applied in chemistry earlier, that is when students are still in 10th grade, so we will not be left behind from other school students. I was so happy because I was given the opportunity to take part in learning chemistry using STEM model, I gained a lot of experience and knowledge which could improve the ability to solve various problems. My wish is to continue this program because it really helps me through the learning process. By having a lot of knowledge, we can also be better in knowing which parts we are still lacking and how to fix them. Let's continue learning chemistry with STEM.

Most of students think that STEM-PjBL model can improve the ability to answer questions related to acid-base indicator material problems, increase understanding of scientific methods used by scientists in investigation or discovery, and improve STEM skills. This approach also aligns with the opinion of Afriana (2015), that states:

"The existence of the latest technology is needed in creating creative projects. The relationship between science, technology, and other sciences cannot be separated when learning science. STEM integrated in the PjBL will be able to cultivate 21st century skills in preparing for the golden generation of Indonesia. The STEM approach prepares students with the skills required for 21st-century competition, such as technological skills, communication skills and problem solving."

The STEM approach is suitable for exploring the topic of natural acid-base indicators because students utilise abundant natural resources in their environment, including various plan parts (flowers, leaves, fruit), as well as fruit peel waste. This approach enables them to address problems that arise, such as reducing pollution from organic waste and adding value to it, while also identifying the acid-base properties of food. In line with Herliani, et al (2021) that in addition, STEM Local Context allows students to identify problems related to the processing of natural resources that are abundant in their area, thus contributing to the welfare of the surrounding community. STEM knowledge in the topic of natural acid-base indicators includes:

- Science (S): How to determine the acid and base properties of a substance.
- Technology (T): The use of natural acid-base indicator in the form of simple test kits made from paper, dacron, or extract paste, etc.
- Engineering (E): The process of creating natural acid-base indicators from plant or fruit peel waste.
- Mathematics (M): determining the acidic or basic pH of a substance and graphing changes in pH

The majority of students also argue that learning with STEM is difficult. It was because this model was the first experience for them to be unfamiliar. In addition, due to the investigation steps in this model make the students feel difficulties, especially for students with low levels of cognitive ability. As stated by Han, et al. (2015):

"The participating teachers indicated that student readiness was a critical factor in implementing STEM PBL. In other words, teachers had difficulties in effectively implementing STEM PBL with students who were not academically ready. Students in the three participating schools demonstrated low academic achievement in mathematics on standardized state tests and came from lower economic backgrounds compare to those in other areas of the same region. Based on previous research, STEM PBL was found to be more effective in learning environments with low achievers. However, the implementation of STEM PBL with low achievers exhibiting behavioural issues was challenging for the teachers in this study. The teachers believed that the low achieving students lack familiarity with a student-driven learning environment would be another challenge in STEM PBL implementation."

In this research most students also find learning with this STEM-PjBL difficult. That's because this model is their first experience, so they are not used to it. In addition, because the investigation step in this model possesses difficulties for students, especially in students with low cognitive levels. Therefore, the learning model using STEM-PjBL in acid-base indicator material can be utilised as one of various engaging learning, methods for students. Teachers need to provide guidance and motivate students with low cognitive abilities so that they will become more accustomed to and have no difficulty in learning with other STEM-PjBL model.

1. The Use of Natural Materials from the Surrounding Environment

The mastery of student concept is also necessary for students to be able to answer the questions correctly. One way to bring students closer to their daily environment. In the concept of acid-base identification, there are 2 (two) types of indicators, those are natural and artificial indicators. Natural indicators are derived from leaves, flowers, rhizomes and other parts of plants which is exist in nature. Based on the condition of each group, the plants used include *Bougainville* flowers, *sechium edule*, orange peels, *pandanus* leaves, mangosteen peels, and *alternanthera* leaves.

In general, those materials are easily obtained by students, such as decorative plants grown in their yard or garden, or from their immediate environment. They can utilise waste materials such as orange peel and mangosteen peel. The ingredients are then processed in several ways:

a. pound the peels (e.g., orange peel, mangosteen peel) using a mortar and pestle until it is smooth, add a small amount distilled water have it filtered to get the extract;
b. boil the extract first, then let it cool at room temperature.

The extracts were then tested on several solutions, namely: HCl, H_2SO_4, NaOH, detergent water, promag drugs, tomatoes, dishwash, and vinegar depending on the choice of each group. The following are the results of each group.

Table.1. Student Observation Results

Group	Natural Materials	Extract colour	Colour in acid solution	Colour in base solution
1	*Bougainvillea*	pink	bright purple	greenish yellow
2	*Sechium edule*	green	bright green	green
3	Orange peel	yellow	yellow	bright yellow
4	*Pandanus* leaf	yellowish green	bright yellow	yellow
5	Mangosteen peel	brownish purple	pink orange	gold yellow
6	*Alternanthera* leaf	purple	pink	brownish green

Based on the results of those experiments, the extracts of natural ingredients that can be used as indicators of acid-base are mangosteen peel, *Bougainvillea*, and *Alternanthera* leaf. It is because these three extracts gave a different colour when added to acidic or basic solutions, while the other ingredients did not show contrasting colour difference. The lack of contrasting colour could be attributed to suboptimal extraction processes. In a study conducted by Wasito, et al. (2017), the extraction process for various natural ingredients begins with washing all parts of the plant, reducing its size by cutting, and subsequently drying under the sun while covered with a black cloth. The dried plants or simplicia were then pulverized and extracted to maceration using a 96% ethanol solvent for a day. However, the students did not follow this elaborate procedure and instead opted for a simpler approach in extracting the natural ingredients. Based on the results of the assessment of acid-base indicator tests, that the following observations were made:

- 82% of students demonstrated knowledge of the definition of acid-base indicators
- 45% of students were aware of the types of acid-base indicators based on their source/method of manufacture
- 42% of students understood that not all natural ingredients can be used as indicators of acid-base reactions

Hence, the students exhibited a strong understanding of the definition of acid-base indicators. However, there is a lack of understanding regarding artificial and natural indicators, as well as the types of natural materials that can be used as indicators. Indeed, it becomes an obstacle in the implementation of PjBLs, as stated by Afriana (2015), namely:

a. students who struggle with experimentation and information gathering may experience difficulties;

b. if the topics given to each group are different, the students may not be able to understand the topic.

Learning with the PjBL model is recommended in the 2013 curriculum because it effectively increase student's interest and involvement in authentic problem-solving, group work, and building solutions for real world issues (Afriana, 2015). However, when implementing the STEM-PjBL model to students who have lower cognitive levels, the teacher needs to exert extra effort to provide guidance and motivate students. This presents a challenge for the teachers (Han et al, 2015).

2. Chemistry Online Learning with the STEM Approach During the Covid-19 Pandemic

Since 2013, due to Distance Learning Program in SMAN 2 Padalarang has commonly using Edmodo, Moodle, SIERRA and SIAJAR. Since 2019, most of teachers in the school have tried to use Edubox. In the middle of March, when the Corona virus invaded Indonesia, learning completely switched to the online system using Edubox. Besides Edubox, various digital services like *Rumah Belajar,* Kahoot, Quizizz, Browser (Chrome), YouTube, Weebex Meeting, and WhatsApp (WA) are used to support online learning at SMAN 2 Padalarang.

At that time the stages of learning chemistry with the new STEM PjBL model were implemented. Fortunately, at that time students had successfully tested the research design to create indicators of natural acid base. Due the rule of social distancing, students were unable to correct and repeat experiments, so we immediately moved to the communication stage. I guided students in analysing the results of their research trials through the WA Group. We then proceeded to the communication stage with video conference via Cisco Webex. Furthermore, learning was evaluated through Edubox and Google Forms. There is documentation of learning chemistry with the STEM approach online during the COVID-19 pandemic.

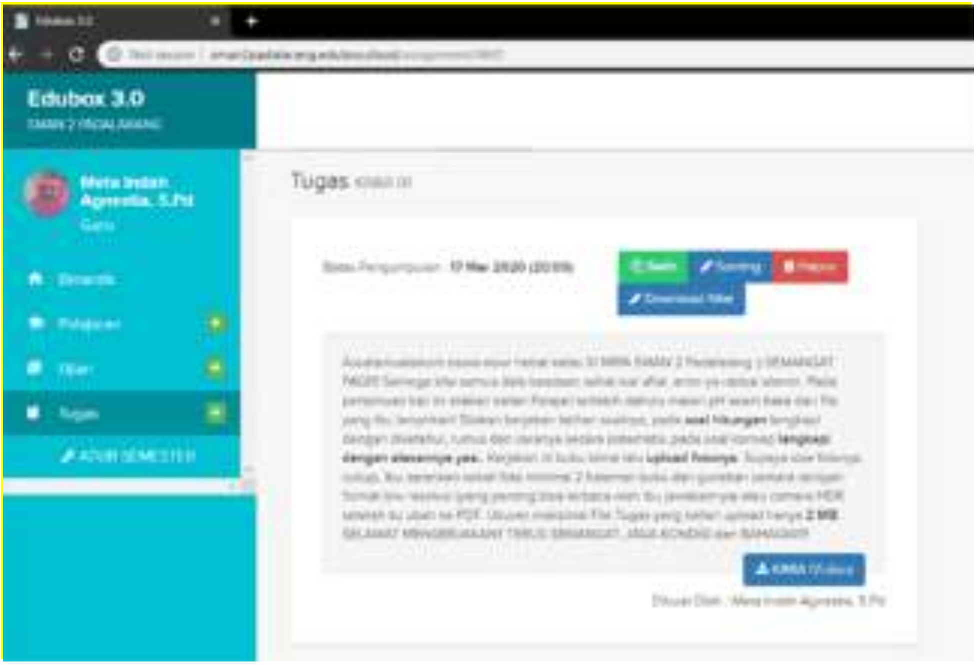

Figure 6. learning with Edubox applicatio

All groups planned to produce products in the form of simple acid-base indicator, which are easy to make and used for testing acidic/base substances. The props would be made in various forms of test paper, test equipment made from dacron, and test equipment in the form of paste from the extract.

Although the product in the form of acid-base test equipment came from natural materials has not been successfully made, students have managed to find natural ingredients that can be used as indicators of natural acid-base. Out of the six (6) tested natural ingredients, only three (3) samples can be used as indicators of natural acid base. Failure is considered a natural part of the design process and an important step towards finding a successful solution (Jolly, 2017).

Therefore, the learning phases have been achieved through the STEM approach by obtaining the output of the process and the discovery of new types of natural materials that can be used as a reference indicators of natural acid base. Besides that, students have successfully achieved the following learning outcomes:

3.10.1 Determine natural materials that can be used as indicators.

3.10.2 Identify the colour change of the indicator in various solutions.

3.10.3 Identify several acid-base solutions with several indicators.

4.10.1 Identify problems related to healthy canteens.

4.10.2 Develop the best procedure for testing healthy foods based on pH criteria.

Conclusion

The STEM approach can be used as a variation in chemistry learning so that students feel happy and interested in mastering chemical concepts. The STEM approach can be utilised in online learning during the COVID-19 pandemic. The teacher guides students to analyse experimental and communication data uses the Cisco Webex, Edubox, and WA Group applications. Plant parts come from the environment around students can be used as indicators of natural acid-base properties, but student's knowledge about the nature of acid-base in school snacks is not yet known. It is because students cannot conduct the test due to the enforcement of social restrictions during the COVID-19 period.

Acknowledgements

I would like to extend my heartfelt gratitude to Tuti Kurniawati, M.Pd. and Dr. Toto Suharya, S.Pd., M.Pd. as the principals of SMAN 2 Padalarang, and also my partner Desy and the teachers and pupils who have been highly supportive during this learning process.

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2023
SciEd
SEAQIS Journal of Science Education (SciEd)
E-ISSN: 2964-7533
Vol: 3, No: 1, PP 46-52
www.journal.qitepinscience.org
Research Paper
Open Access

Investigating Students' Logical Thinking Abilities on Chemistry Learning

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Abstract

The purpose of this study is to map students' logical thinking abilities for learning chemistry. A total of 39 eleventh grade students of SMK-SPP Negeri Samarinda in Agribusiness and Horticulture Program participated in the study. Test of Logical Thinking (TOLT) was administered to determine students' reasoning abilities. Quantitative descriptive method was used to analyse the data. The result shows that 84,62 % students were found in the concrete level. It consists of 58,97 % male students and 25,64 % female students. Further, 7,69 % male students were found in the transition level and 7,69 % students were found in the formal level, each 2,56 % male and 5,13 % female. From the data, it can be concluded that the majority of students have the concrete level of logical thinking.

Keywords: logical thinking abilities, Piaget, students' logical thinking

Introduction

The success of learning process is influenced by the fit between the subject matter and the students' level of thinking ability. Students' thinking ability greatly affects the success of achieving learning objectives. According to Piaget in Simatwa (2010), every individual has different cognitive development levels. Piaget stresses that as children mature mentally, they pass through four major stages of cognitive development sequentially, with each stage having several sub stages. The major stages of cognitive growth are: sensory motor stage (0 - 2 years), preoperational or intuitive stage (2 - 7 years), concrete operations stage (7 - 11 years), and formal operations stage (11 - 15 years) (Simatwa, 2010). Formal reasoning is characterized by the ability to think about abstract ideas, organise ideas, think logically, and reason about what will happen later.

The relationship between prior knowledge, reasoning ability, achievement, and gender has received special attention in science education research for many years (Yenilmez et al., 2006). Throughout the courses taught in elementary and middle school, 'science' is the one requiring intellectual skills to collect and analyse data to solve problems. In fact, science process skills taught in elementary grades such as observing, classifying, and collecting data act as prerequisites for integrating the processes usually taught in middle school grades like hypothesising, controlling variables, and defining operations (Yenilmez et al., 2005).

Chemistry is one of the most important parts of science that makes the students understand what is happening around them. Chemistry relates generally to the structure of matter. Chemistry combines many abstract concepts, which is the basic knowledge to learn more about chemistry and other sciences (Taber, 2009). The chemistry curriculum commonly incorporates many abstract concepts, which are the central focus of more advanced learning in both chemistry and other sciences (Taber, 2009; Sirhan, 2007). Abstract concepts are important because further chemical science concepts or subsequent theories could not be understood easily if the abstract concepts are not well understood by the students (Sirhan, 2007). Empirical studies (e.g., Ben-Zvi, Eylon, and Silberstein, 1986, 1987) have shown that learning microscopic and symbolic representations are especially difficult for students because these representations are invisible and abstract while students' understanding of chemistry relies heavily on sensory information (Wu et al., 2000).

The concept still aligned with the level of students' thinking which has entered formal thinking according Piaget’s level that the ages of 11-15 years and over are able to think abstractly. Ben-Zvi, Eylon, dan Silberstein in Wu, Krajcik & Soloway (2000) find many senior high school students who has not reached that level of thinking having difficulties in understanding chemical concepts. As a result, students who studied chemistry just memorize chemistry concepts without understanding the concepts.

Throughout the courses taught in elementary and middle school, ‘science’ is the one requiring intellectual skills to collect and analyse data to solve problems. Flavell mentions that Jean Piaget’s theory of intellectual development in Simatwa (2010) is considered a leading theory on cognitive development.

Piaget viewed constructivism as a way of explaining how people come to know about their world. He buttressed this explanation with extensive documentation of behaviours he witnessed, and with well supported inferences about the functions of the mind. Piaget (1952) viewed the human mind as a dynamic set of cognitive structures that helps us make sense of what we perceive (Brooks, J. G., & Brooks, M. G, 1999).

Piaget (1952) also states that children are considered ready to develop a concept or special material when they obtain the necessary schemata. This means that children cannot learn if they do not have the cognitive skills. This also means that the learning process becomes blocked when students do not have the required formal reasoning.

SMK-SPP Negeri Samarinda have their own mapping in recruiting their students based on the farming region spread in East Kalimantan, so they have students with very diverse backgrounds. The teachers’ ignorance of the cognitive development theory will result in having to solve problems with experiential learning and following the teacher's intuition.

As a result, it is necessary to conduct research on cognitive development according to Piaget’s levels. This is due to the fact that according to their age, they should have been in the thinking stage of formal operations (Simatwa, 2010). The teachers’ knowledge of the students’ cognitive development made the teachers able to plan the exact method that can be used in the learning process that happens in the classroom.

Methodology

Sample

A total of 39 eleventh grade students (27 male and 12 female) of SMK-SPP Negeri Samarinda in Agribusiness and Horticulture Program participated in the study.

Instrument

The Test of Logical Thinking (TOLT) developed by Tobin and Capie (1981), was used to determine the formal reasoning ability of students. The test consists of ten items designed to measure proportional variables (1-2), controlling variables (3-4), probabilistic variables (5-6), correlational variables (7-8), and combinational reasoning (9-10). Students select a response from among five possibilities and then they are provided with five justifications to choose from (Yenilmez et al., 2006). In the first 8 questions, the student is asked to provide the correct answer and the reason why this answer is correct. Both the answer and the reason must be correct for the student to be awarded a credit. The last 2 questions involve combinational reasoning and require the student to enumerate the possibilities. The score on the TOLT is an integer value between 0 and 10. For each question correctly answered, the student receives 1 point, and for each question with a wrong answer, the student receives 0 point (Etzler and Madden, 2014).

Procedure

In each class, students are informed about the purpose of the questionnaire and the procedure for completion. After this short explanation, the answer sheets were distributed, and students were required to complete their personal background information and think about each question and answer it as how it applies to them. Then, the TOLT tests were distributed and students were asked to complete the questions on their own. It took about 40 minutes for students to complete the test.

Data Analysis

This research was a descriptive quantitative study. The research described the mapping of formal thinking skills in the eleventh graders of Agribusiness and Horticulture Program of SMK-SPPN Samarinda.

Results

The TOLT scores of the 39 students ranged from 0 to 5. The age of the students taking the test was 15-18 years. Nevertheless, age of the students was not a significant factor relating to the TOLT score. Sixty-nine percent of the students taking the TOLT were male. There was no significant difference between TOLT score and gender and the average TOLT scores of each gender were nearly the same.

Descriptive statistics are used to see the distribution of student's TOLT results as shown in Figure 1, Figure 2 and Figure 3. In this study, the performance of students at TOLT was also used to categorise the stages of cognitive development by Piaget, divided by stages such as concrete level, transition, and formal. Formal stage was also divided into two parts: the formal stages and the final formal stages (Valanides, 1997). The results are presented in Figure 1.

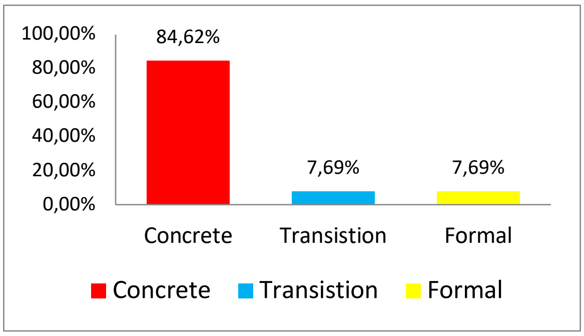

Figure 1. Students Mapping Cognitive Development

Students 'cognitive development, mapped by gender differences were presented in Figure 2. As shown in Figure 2, there is not a lot of students that have reached the formal operational stage. Of the total study sample of 39 people, as many as 33 students were at the level of concrete thinking (84,62%), three students were at the transition level of thinking (7,69%) and 3 students were at the early formal level of thinking (7,69%). The percentages of the male students in the concrete and transition level of thinking are higher than the female students. Even though the highest percentage in the formal level were the male students.

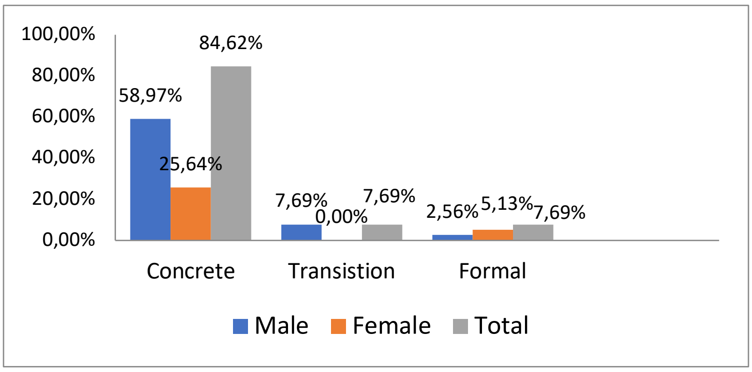

Figure 2. Students Cognitive Development Mapped by gender

The mapping of students' four stages of cognitive development by gender were presented in figure 3.

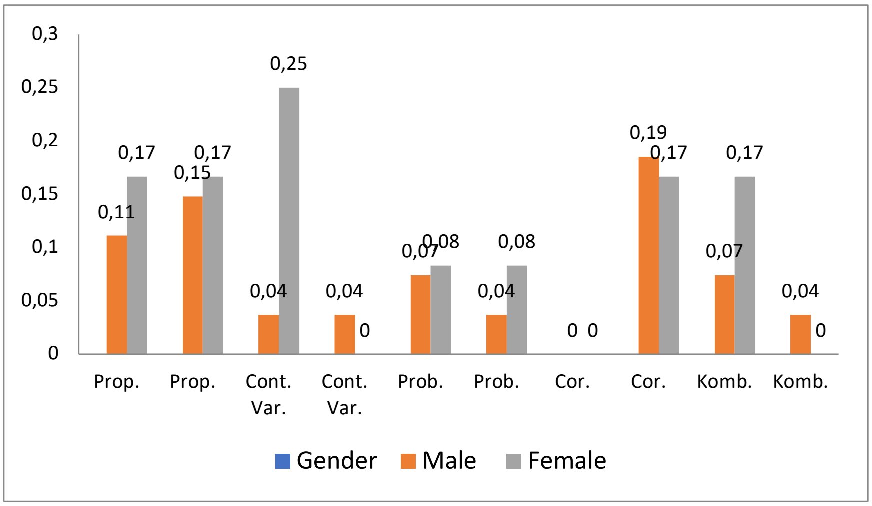

Figure 3. Students Mapping Cognitive Development Male and Female

Based on figure 3, female students scored higher than male students in the proportional logic level, controlling, probabilistic, and combinational reasoning. However, in the correlational level, male students scored higher than female students.

Discussion

If categorised in stages of cognitive development, only few students have entered the formal stage. Most of students are at the concrete stage meaning that they are still unable to predict the final answers therefore any data and information are geared to achieve that goal.

The thinking ability of students who have not entered the stage of formal thinking would make them difficult to understand chemistry. Because chemistry generally combines many abstract concepts, which are the basis of knowledge to learn more about chemistry and other sciences (Taber, 2009).

Individual differences in cognitive development refers to the difference in capacity and speed of learning chemistry. Individual differences of learners will be reflected on the nature or characteristics of their abilities, skills, attitudes and habits of learning, as well as the quality of the learning process and results, either in terms of cognitive, affective and psychomotor.

The teaching methodology and materials with learning activities should be appropriate to each of the learners' cognitive developmental stages. It is stated in the theory that there is a mutual interaction between the learner and the environment, thus teaching materials should come from the learner's environment (Simatwa, 2010). The learning model that we can use is contextual learning model or could be combined with other learning model that is essentially rooted in the daily lives of the students.

Teachers as instructional managers should use the hierarchy to understand why children think and reason as they do and to help the pupils' master intellectual processes at the appropriate age (Simatwa, 2010). Each student has different intellectual capacity, in the same way children at various ages have different capacities for attention and comprehensive.

Piaget opined that teachers as learning managers need to ensure that the learning environment should be rich in physical experiences since intellectual development stage depends on student activity which is the key to intellectual development. How teachers manage the class will be visible from students' independency and creativity in classroom (Brooks & Brooks, 1999). Curriculum, learning and task developers must bring out exceptional effort to understand the world of children. They shall not assume that what they find good for children is certainly good for the child. They can design an educational experience based on the needs and readiness of children (Simatwa, 2010).

Chemistry teachers' understanding of students' logical ability thinking can improve teachers plan learning chemistry and stimulate students' ability to think logically. For instance, teacher can use multimedia to explain abstract concepts in chemistry learning.

Here are some practices that can boost students cognitive functioning in memorising, understanding, and applying knowledge of chemistry or other science.

1. Create a relevant learning and recall the prior knowledge.

Use the early teaching method (analogy, elaboration) with students to help stimulate their previous knowledge. Teacher can use image or animation to present the microscopic level in chemistry matter. The cognitive processes involved in comprehending a visual image can be described on various levels. At minimum level, they include: (a) identifying the important features of a visual display, which is referred to as a surface-level processing or external identification; (b) relating the visual features to their meaning, i.e., semantic processing; and (c) constructing the communicated message, i.e., pragmatic processing (Plass, Homer and Hayward, 2009).

2. Organise information.

Teacher should be well informed on how the students interpret ideas occurred during the class by encouraging a free discussion. They should also watch for the tendency of the adolescent to indulge in unrestrained and unrealistic political theorising where teachers must handle such immature forms of thinking by helping students to recognise that they have overlooked certain boundaries. Another example is teachers are required to classify specific issues under a more general problem.

3. Utilise questioning techniques.

4. Questions appearance prior to the introduction of teaching materials is necessary in helping students to learn the learning material. Teachers are demanded to encourage student curiosity by asking questions, open discussions, and encourage students to apply for a review question one to another. Teachers needs to always engage students through experiences which could create different viewpoint between each student, therefore there will be a discussion of various hypotheses and perspectives. On one side, teachers are not able to know what will be perceived as a disagreement for the students for itis an internal process. On the

other side, teachers are able and should challenge students' conceptions considering that the challenge only take place if the student form different ideas among them. Teachers directs the student's perspective to help them understand what the idea of another student and enable them to accept or to reject the conflicting views (Brooks & Brooks, 1999).

5. The further analysis revealed that dynamic visualisations are more effective than static visualizations only when they are of a representational rather than decorative nature, therefore it is suggested to use interactive multimedia to introduce abstract concepts. The analysis also showed a larger benefit of dynamic over static visualizations when the target knowledge was procedural motor knowledge rather than procedural or declarative knowledge (Plass, Homer, and Hayward, 2009).

Some of the practices above can be applied by teachers to help the cognitive functioning of students in chemistry and learning in general. As for the effects of these practices, students will find it easier to process information and knowledge which will bring advantage on their learning outcomes as well.

Conclusions

The study concludes that within the total study sample of39 people as many as 33 students are at the level of concrete thinking (84,61%), three students at the level of thinking transition (7,69%) and three students are at the level of formal thinking (7,69%).

Chemistry teacher plays an important role in helping and facilitating their students to learn chemistry in accordance to their ability and cognitive development. Teachers, as the manager of chemistry learning in class, should ensure that the learning environment is rich in physical experiences for growth in one stage depending on the many activities.

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