Development of a supplementary material on modes of heat transfer for STEM learning among grade 7 students

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Abstract. This study was conducted to develop a supplementary material on the modes of heat transfer for promoting STEM learning among grade 7 students. The supplementary material went through the following stages of development: identification of the topic, draft, evaluation by the thesis adviser and panel members, revision, final evaluation by the in-service teachers and pre-service teachers, test for readability, and final revision. The developed supplementary material was found suited for the Grade 7 students by the use of the McLaughlin SMOG formula for the readability. Hence, the supplementary material is highly commendable as an instructional material and it can be a tool for promoting an effective STEM learning.

1. The Problem and Its Scope

1.1. Introduction

Different groups of students have different needs, both on a personal level, and a class level. If a teacher follows the structure set out by the author(s) of a textbook, the teacher may be curbed in their creativity as to how best to reach the students in their classes [1]. Furthermore, the textbook may not be relevant or interesting enough to motivate the students [2]. Therefore, the teacher needs to supplement materials to promote motivation, which is one of the key factors of learning.

A supplementary material is an appropriate instructional material as it can make classes more interesting and motivating if correctly selected at the moment of planning the lesson [3]. Using supplementary materials challenges teachers and students to go beyond the prescribed curriculum. It is like putting into practice the learned concepts, skills and values in real life [4].

Supplementary materials help teachers produce learners who are able to go beyond the textbook into real life. They add to the information in the textbook and carefully follow the content. These materials give teachers new ideas that are researched to be sure they do what they need to do [5].

1.2. Objective of the Study

This study aims to develop a supplementary material on modes of heat transfer as a tool for promoting an effective STEM learning among Grade 7 students.

1.3. Scope and Limitation of the Study

This study focused on the development of a supplementary material on modes of heat transfer for grade 7 students under the K-12 Curriculum. The content of this supplementary material includes the modes of heat transfer, namely the radiation, convection, and conduction. This research was conducted to the in-service Science teachers from public high schools within the vicinity of Iligan City and pre-service Physics Major Education students from Mindanao State University- Iligan Institute of Technology.
1.4. Statement of the Problem

The following questions are the bases of this study:

1. What are the revisions made to the material after evaluation?
2. What are the ratings of the in-service and pre-service teachers on the developed supplementary material in terms of the following?
   a. Cover page
   b. Introduction
   c. Illustration
   d. Overall content
   e. Self-assessment questions
3. What is the readability of the developed supplementary material?
4. What are the comments and suggestions of the evaluators on the developed supplementary material?
   a. In-service teachers
   b. Pre-service teachers

2. Related Literature and Studies

Students may hold a variety of misconceptions about heat, temperature, and energy. A few common misconceptions include the idea that some objects, such as blankets, produce their own heat. Students may believe this because they have experienced feeling warmer after covering themselves with a blanket or putting on a sweater. Another area of misconception deals with the words “hot” and “cold”. Students often believe that heat and cold are different, and that they are substances rather than energy. Students may also believe that “cold” is transferred from one object to another – their experience with coolers and refrigerators seems to confirm this misconception. Knowledge of heat transfer, in conjunction with other science, has proven that technology can advance. To be a human that consumes energy having knowledge on heat transfer is required. To make future life on earth better for seven billion plus people, knowledge of heat transfer is a requirement [6].

It has been asserted by the researchers that students consider the concepts in physics too abstract to understand. Moreover, teachers also believed that students must have a high level of competency in mathematics to understand physics concept better [7], [11]. In another study, teachers have emphasized that students need to possess mathematics competency to understand physics better [8].

Textbooks are regarded as the core of teaching materials and serve as a pivotal role to facilitate the instructors’ teaching in classroom settings [1]. Teachers use textbooks to instruct students [9]. Books give information, but they do not provide students a means of moving that information off the page and into real life. Materials and activities that ask the student to move beyond the textbook help them learn [10].

Supplementary materials offer wide range of ideas, concepts, perspectives and ways of creating and communicating information and knowledge [4]. According to UNESCO, Supplementary materials are both learning and teaching materials (LTMs) that are concrete, tangible vehicles for supporting students learning.

3. Methodology

3.1. Subjects of the Study

Twenty-five (25) in-service teachers who are teaching Physics subject from the following secondary schools in Iligan City: Iligan City National High School, Iligan City East National High School, Iligan City National High School of Fisheries, Ma. Cristina National High School, Tomas Cabili National High School and twenty-five (25) pre-service BSE-Physics teachers of the Department of Science and Mathematics Education of College of Education of Mindanao State University- Iligan Institute of Technology were the respondents of the study.
3.2. Research Design
This study made use of research and development design wherein the researchers developed a supplementary material for Grade 7 students to promote STEM learning. The topic Heat Transfer was chosen because many students tend to have misconceptions regarding the topic. The supplementary material went through the following stages of development: identification of the topic, draft, evaluation to be done by the thesis adviser and panel members, revision, final evaluation to be done by the in-service teachers and pre-service teachers, test for the readability and rubric, and final revision.

3.3. Instruments Used
The instruments used in this study were adapted rubric and questionnaire for the evaluation of the efficiency of the developed supplementary material as an instructional material for Grade 7 students in stud. The rubric consisted of eleven (11) criteria with the ratings 5, 4, 3, 2, and 1 as Excellent, Very Good, Good, Fair, and Poor, respectively. Mean rating interval determined the overall remarks of the respondents. The questionnaire was the basis on knowing the evaluators’ perceptions on the supplementary material and their comments. Aside from the rubric, McLaughlin SMOG (Simple Measure of Gobbledygook) Readability Test was used to check the efficiency and understanding of the developed supplementary material.

3.4. Data Gathering Procedure
With the consent from the school principals, the researchers disseminate the developed supplementary material together with the rubric and the questionnaire to the in-service teachers from the five (5) public high schools namely—Iligan City National High School, Iligan City East National High School, Iligan City National High School of Fisheries, Ma. Cristina National High School, and Tomas Cabili National High School. Moreover, the researchers also gathered data from the twenty-five (25) pre-service teachers major in Physics Education from Mindanao State University – Iligan Institute of Technology. After having the result from both the in-service teachers and the pre-service teachers, the data were analyzed.

3.5. Statistical Analysis
The Arithmetic Mean was used to represent the clustering of the scores of the individual observation using rubric. To interpret the ratings given on the criteria of the rubric found on the supplementary material, intervals were used. Each interval has equivalent or corresponding remark. Every criterion in the rubric used by the teacher was given points: 5 being the highest and 1 being the lowest. Afterwards, computation of the mean rating was done and interpreted as follows: 1.00 – 1.79 (Poor); 1.80 – 2.59 (Fair); 2.60 – 3.39 (Good); 3.40 – 4.19 (Very Good); 4.20 – 5.00 (Excellent).

4. Results and Discussions
4.1. The Supplementary Material
The topic of the supplementary material was based on the K-12 Science Curriculum Guide of Department of Education in the Philippines. The topic heat transfer fell under the second quarter with the subtopics conduction, convection and radiation.

The first draft included the writing of the content and the design making of the supplementary material. Important parts of the supplementary material were made during this stage. This included the division of lessons for each mode of heat transfer, formulation of objectives, and selection of the contents by the use of different science books and web sources, selection of relevant illustrations and diagrams, formulation of self-assessment questions, observance of correct grammar usage and organization of the entire supplementary material.

The developed supplementary material underwent first evaluation which was done by the thesis adviser and panel members to verify if the contents, design and illustrations used for the supplementary material are appropriate for the topic Modes of Heat Transfer. The revision for the developed supplementary material was done based on the recommendations of the panel members and thesis adviser.

The comments and recommendations of the panel members and the thesis adviser were taken into consideration for the improvement of the supplementary material together with some changes in the sentence constructions due to grammatical errors. There were improvements done in the layout to enhance the overall appearance of the supplementary material.
Figure 1. Changes on the cover page.

Figure 1 shows that the illustrations from the cover page photo were removed to avoid cluttering. Author’s name and publication date were also added. This is to emphasize the title, authors and the publication date.

Figure 2. Changes on the introduction.

Figure 2 shows that the brief introduction was changed in order to match with the entire season in a year rather than focusing on the Christmas season.
Figure 3. Changes on lesson 1 activity.

Figure 3 shows that there were changes made in the pictures. Local pictures were used instead of using the pictures found in the internet. The researchers took their own pictures to avoid plagiarism, since pictures on the internet are mostly copyrighted.

Figure 4 and Figure 5 show that the example for the subtopic convection was replaced with simpler example and more vivid illustration. From the boiling water example and illustration it was replaced with the sea breeze and land breeze phenomena. It was to provide better understanding of the topic.
Figure 6. Changes on the radiation part.

Figure 6 shows that instead of using the clipart from the internet, local picture was used. It was done to avoid misconception that the researchers are advertising the said clipart. The clipart was replaced with a thinking girl.

Figure 7. Changes on the radiation part.

Figure 7 shows that more arrows were added to emphasize the direction of the heat. Since heat does not only emit on the direction of the three arrows on the first picture, it emits in all direction. Thus, arrows that point in all direction were added.

Figure 8. Changes on references.

Figure 8 shows that the links of the sources on the first picture were just randomly put on the page. On the second picture, the links of the sources were arranged in an APA format. Cover references were separated from Content references.
4.2. Final Evaluation

The final evaluation stage is the important part in the development of the material since this stage includes the rating of the whole supplementary material as a self-instructional tool for the students. In-service teachers of Iligan City National High School, Iligan City East National High School, Iligan City National High School of Fisheries, Ma. Cristina National High School, Tomas Cabili National High School and pre-service teachers of MSU-IIT were the evaluators of the supplementary material through the use of rubric and a questionnaire. The results of their ratings are shown in Table 1.

Table 1. Ratings of the in-service and pre-service teachers on the supplementary material.

| Criteria                     | In-service Teachers | Pre-service Teachers | Mean Rating | Remarks |
|------------------------------|--------------------|----------------------|-------------|---------|
| I. Cover page                |                    |                      |             |         |
| A. Appropriateness           | 4.72               | 4.58                 | 4.65        | Excellent |
| B. Attractiveness            | 4.56               | 4.20                 | 4.38        | Excellent |
| II. Introduction             |                    |                      |             |         |
| A. Motivation                | 4.52               | 4.52                 | 4.52        | Excellent |
| III. Illustration            |                    |                      |             |         |
| A. Design                    | 4.58               | 4.32                 | 4.35        | Excellent |
| IV. Overall Content          |                    |                      |             |         |
| A. Objectives                | 4.68               | 4.48                 | 4.58        | Excellent |
| B. Emphasis                  | 4.76               | 4.68                 | 4.72        | Excellent |
| C. Scope                     | 4.64               | 4.72                 | 4.68        | Excellent |
| D. Accuracy                  | 4.80               | 4.68                 | 4.74        | Excellent |
| E. Relevance                 | 4.76               | 4.64                 | 4.70        | Excellent |
| V. Self-assessment Questions |                    |                      |             |         |
| A. Relevance                 | 4.88               | 4.52                 | 4.70        | Excellent |
| B. Activity/Examples         | 4.80               | 4.60                 | 4.70        | Excellent |

Legend: 4.20 – 5.00 (Excellent); 3.40 – 4.19 (Very Good); 2.60 – 3.39 (Good); 1.80 – 2.59 (Fair); 1.00 – 1.79 (Poor)

Table 1 presents that the ratings of the supplementary material in the cover page, introduction, overall content and self-assessment questions were excellent. This means that the cover page of the supplementary material on every lesson is related to the content and it made excellent use of fonts, color, graphics, and designs. The introduction foretells the overview of the topic on every lesson. The graphics used were interesting and well arranged. For the overall content, the objectives on every lesson were clearly stated. The significance of the modes of heat transfer was emphasized. The scope was achieved and the information and discussions were all accurate and relevant. Furthermore, the questions for self-assessment, examples and/or activities were easy to understand and were related to the objectives and the topic. This shows that both the in-service and pre-service teachers had the same view with regards to the suitability of the supplementary material as an aid for the grade 7 students in studying the modes of heat transfer.

4.3. In-service Teachers Comments and Suggestions on the Supplementary Material with Regards to the Cover Page, Introduction, Illustrations, Over-all Content and Self-assessment Questions

The in-service teachers suggested that:

1. The pictures must be labelled.
   - You should add labels/descriptions on the localized pictures to avoid confusion.
   - Put descriptions on the picture in the activities.

2. Some of the font size should be adjusted.
   - The font size on some parts should be bigger than this.
   - Font size is too small.
4.4. The In-service Teachers Qualitative Rating on the Supplementary Material on the Modes of Heat Transfer for Grade 7 Students

- Appropriateness of the supplementary material on the target grade level
  “Yes, because the topic/lesson is included or within the content of grade 7 lessons.” – IST_7
  “Yes, though Physics can be considered as a difficult subject but unexpectedly the language usage suits their level of comprehension.” – IST_5
  “Yes, K to 12 Based material that addresses the interests and abilities of the 21st century learners.” – IST_16
  “Yes because it has the necessary information needed for heat transfer and can easily be understood. I find it very helpful and appropriate for heat transfer lesson.” – IST_21

- Deficiencies and errors found on the supplementary material.
  “The cover should be catchy or attractive for grade 7 students.” – IST_9
  “The term used like the hour, change it to minutes or seconds because hour is too long.” – IST_11
  “The pictures used are somewhat placed awkwardly and does not really fit the theme.” – IST_24

- Contents suffice the objectives needed to attain.
  “Yes, the objectives are clearly stated.” – IST_6
  “Yes. The objectives in every lesson are achieved.” – IST_12

- The supplementary material is recommendable as an instructional material.
  “Yes, it’s sufficient. It is also fits with the classroom setting.” – IST_6
  “Yes, the lessons are well discussed. It could be a great instructional tool instead of the textbook.” – IST_13
  “Yes, it would be a great help for both the students and teachers. Especially nowadays that teaching is student-centered. Students have the freedom to explore the lessons.” – IST_20

- The graphics used are relevant.
  “Yes they are relevant but still some pictures are either too big or too small.” – IST_7
  “Yes. The pictures are relevant with regards to the concept/topic.” – IST_10
  “Yes, but some pictures are awkwardly placed and are too dark for the booklet theme.” – IST_14

4.5. The Pre-service Teachers Comments and Suggestions on the Supplementary Material with regard to the Cover Page, Introduction, Illustrations, Over-all Content and Self-assessment Questions

The pre-service teachers suggested that:
1. The pictures must be labelled.
   - I think it will be better if there are few descriptions/labels on the pictures.
   - Some pictures cannot be guessed with a glance. Label is needed.
2. Some of the font size should be adjusted.
   - Some word are too small, I need to squint my eyes to see it!
   - The font size should be consistent on some points.

4.6. The Pre-service Teachers Qualitative Rating on the Supplementary Material on the Modes of Heat Transfer for Grade 7 Students

- Appropriateness of the supplementary material on the target grade level
  “Yes, because it is appropriate in the said grade level.” – PST_11
  “Yes. It is simplified.” – PST_8
  “Yes, it fits the target grade level.” – PST_9
  “Yes, it uses simple terms and explains the lesson in simplest way possible.” – PST_20
- Deficiencies and errors found on the supplementary material
  “Beware of the typo errors.” – PST19
  “Be careful in cutting words.” – PST13
  “Some pictures does not fit with the booklet’s theme.” – PST16

- Contents suffice the objectives needed to attain.
  “Yes, the objectives are clear.” – PST5
  “Yes. It is explained well” – PST1

- The supplementary material is recommendable as an instructional material.
  “Yes, it’s highly recommended.” – PST7
  “Yes, it will be very helpful.” – PST4
  “Yes, I think the teachers would certainly considered it as a helpful instructional tool.” – PST17

- The graphics used are relevant.
  “Yes, it is relevant.” – PST25
  “The drawings are good and are relevant to the concept presented.” – PST15

4.7. Readability of the Supplementary Material using McLaughlin “SMOG” Formula

| Number of polysyllabic words (N) |
|----------------------------------|
| near the beginning (n_b) = 10 words |
| in the middle (n_m) = 8 words |
| near the end (n_e) = 3 words |
| \( N = n_b + n_m + n_e \) |
| \( N = 10 + 8 + 3 \) |
| \( N = 21 \) words |

(Note: the nearest perfect square to 21 is 16. Therefore, \( N = 16 \))

SMOG Formula Grade Level (GL)

\[
GL = 3 + \sqrt{N}
\]

Solution:

\[
GL = 3 + \sqrt{16}
\]

GL = 7

The overall readability of the supplementary material on the modes of heat transfer using the McLaughlin “SMOG” Formula is suited for Grade 7 students.

5. Conclusion

Based on the results of the evaluation, the supplementary material was highly commendable as an instructional material for Heat Transfer. The supplementary material can be a tool for promoting STEM learning among Grade 7 students.

6. References

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