

Development of Web-Based Intelligent Tutoring (*iTutor*) to Help Students Learn Fluid Statics

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Received: 27.10.2015

Revised: 08.03.2016

Accepted: 16.06.2016

The original language of article is English (v.14, n.2, March 2017, pp.1-11) doi: 10.12973/tused.10194a

ABSTRACT

Fluid statics is one of the most difficult topics for students to learn. Formative assessment and remedial instruction can help students master the concepts. However, identifying students' challenges for formative purposes and facilitating remedial learning is not easy given to the number of students and variation of the problems encountered. An alternative solution to overcoming such problems is the use of web-based intelligent tutoring (*iTutor*). This research aims to develop and examine the feasibility and effectiveness of the web-based program *iTutor*. This research project consists of 3 steps, i.e., preliminary study, development, and examination. Three professors, 3 physics teachers, and 74 secondary students participated in this study. The instruments for collecting data included tests, questionnaires, and interviews. The questionnaire and interview data were analysed both quantitatively and qualitatively, while examination data were evaluated by means of an independent t-test. Expert judgment and trial field-testing data confirm the feasibility and effectiveness of using the *iTutor* program to improve students' mastery of physics concepts.

Keywords: formative assessment, intelligent tutoring (*iTutor*), remedial learning, fluid statics

INTRODUCTION

When learning physics, many students have difficulty either understanding the concepts or solving the problems. Some studies reveal that many students have particular difficulty understanding fluid statics. Oftentimes, students misunderstand the concept of Archimedes' Principle (Ünal and Costu, 2005; Yin et al., 2008; Bierman et al., 2003; Loverude et al., 2003; Wagner et al., 2013; Wong et al., 2010; Lima et al., 2014) and hydrostatic pressure (Loverude et al., 2010; Goszewski et al., 2012). Preliminary studies of eleventh-grade students in high school reveal the same results. The students' difficulty in learning this topic can cause them to fail to meet minimum standards.

One way to overcome the problem of student learning difficulties is to implement formative assessment and remedial teaching. Formative assessment can help teachers obtain information about students' learning progress (Bell and Cowie, 2002; Popham, 2008). This



information is useful for students to organize their learning and for teachers to organize and carry out remedial instruction (Lambert and Lines, 2000). This coincides with the recommendation of the *Ministry of Education* No. 66 (2013), which states that students who do not achieve a minimum score should receive remedial instruction. Remedial learning helps students meet the minimum testing standard.

Formative assessment and remedial learning must be applied when learning physics. Because physics consists of many correlated concepts, if one concept is missed, it will be difficult to understand others (Ornek, 2008). Anderson (Chen, 2011) stated that to study effectively, students must organize and build on what they have already learned. This means that, whenever students do not understand a given topic, they should receive remediation in a timely fashion.

However, in the context of learning in Indonesia, the implementation of formative assessment and remedial teaching is not easy. Preliminary results from Kusairi (2012) revealed some difficulties of implementing formative assessment, including the large number of students in every classroom, the time needed to prepare formative assessment instruments, the specialised skills needed for its implementation, and the lack of developed automation systems to support its implementation. An interview with some physics teachers in a high school revealed that current remedial learning lacks adaptability, interaction, and timely feedback due to the high teacher-student ratio, which contributes to the lack of time teachers have to serve every student. Moreover, teachers have too many classes to maximize remedial learning (Jong et al, 2004; Lin, 2007). Implementing formative assessment requires real-time feedback from teachers, which is difficult without the support of adequate tools and technologies (Sorensen and Takle, 2005; Jahjouh, 2014).

Various preliminary studies show the effectiveness of web-based formative assessment. Heinrich et al. (2009) reported that electronic tools help manage assessment for learning (AFL) tasks and promote better time management. Nagel and Eck (2012) found that quizzes and feedback help students master the concepts. Self-assessment in the AFL also had a positive effect on student learning (Basnet et al., 2011). Kusairi et al. (2013) developed a model of web-based AFL that proved to be effective in helping students learn physics (Kusairi and Sujito, 2014).

Instead of using conventional remedial learning methods, we propose an online formative assessment and remedial learning program. The formative assessment and remedial learning use internet technology. Lin et al. (2007) reported that online remedial learning may raise students' learning achievements. They developed online remedial learning in a multimedia format. Demirci (2005) and Chen (2011) used a similar concept to apply online remedial learning to evaluate students' errors.

An excellent program for online assessment and remedial learning is intelligent tutoring (*iTutor*). *iTutor* is a computer-based learning system that can identify student's difficulties and choose the appropriate tutorial to match students' needs (Siemer et al., 1998; Jong et al., 2004). *iTutor* offers some advantages, e.g., (1) offering tutorial programs for an individual or large classes (Lin et al., 2007), (2) identifying students' difficulties in learning and providing quick feedback (Jong et al., 2004), (3) increasing the effectiveness and efficiency of students' learning (Butz et al., 2004), (4) helping students know their weaknesses and strengths (Myneni and Narayanan, 2012), and (5) helping teachers understand each student's development (Lin et al., 2007).

In recent years, various studies have evaluated the use of *iTutor* for learning physics and mathematics (GÜNEL and AŞLIYAN, 2009). Vanlehn et al. (2005) developed an *iTutor* program named *Andes* to increase students' problem solving strategies regarding the topic of force. Mitrovic et al. (2011) developed *Thermo-Tutor* to help students understand the concept

of thermodynamics. In addition, Myneni and Narayanan (2012) developed a virtual physics system (*ViPS*) to overcome students' misconception of the Atwood machine.

Therefore, in this present study, we develop a valid and applicable *iTutor* program and describe its effectiveness.

METHODOLOGY

a. Research Model

This research study included three steps, i.e., (1) preliminary study, (2) development, and (3) examination. The preliminary study consisted of a literature study, field survey, and draft product designing. The development consisted of production, expert validation, and draft revision. The examination consisted of trial field-testing, final revisions, and quasi-experiments. The trial field-testing was meant to evaluate the quality and feasibility of the developed *iTutor* program. The quasi-experiment sought to determine the effectiveness of the web-based *iTutor* program on students' achievement.

b. Population

This study involved three physics lecturers as reviewers of the *iTutor* program, 3 physics teachers as *iTutor* users, and 17 students users who tested the *iTutor* program for 6 weeks. The examination included a quasi-experiment with post-test of control group design. The experimental class consisted of 30 students taught by using of *iTutor*, meanwhile the control class consisted of 27 students taught without *iTutor*. The sample class was X MIA 2 as the experimental class and X MIA 1 as the control class. The topic was fluid statics.

c. Data Collection Tools

The instruments for this research included a questionnaire, interview, and test. The questionnaires and interviews were utilized to collect data on the needs of assessment and remedial teaching undertaken by teachers. The questionnaire was also used to collect data on the validity of the model. The test was used to determine the mastery of the physics concept.

d. Data Analysis

The data obtained were analysed both qualitatively and quantitatively. The data were analysed by calculating the average score using four categories, i.e., excellent, good, fair, and poor. The interview result was descriptively and qualitatively analysed. The post-test score was analysed by means of an independent t-test.

FINDINGS

a. Product Specification

The developed product used the web-based intelligent tutoring system *iTutor*, which is made up of a *back end* for teachers and *front end* for students. Only administrators or teachers can access the back end of the program, which includes a problem bank, remedial notes, quiz management, account management system, and detailed information on student achievements. Students can access the front end of the program, which includes quizzes, feedback, manual solutions, remedial notes, and quiz reports showing their errors and scores.

The quizzes in *iTutor* are multiple-choice. The multiple-choice problems address concepts in fluid statics such as hydrostatic pressure, Pascal's Principle, and Archimedes' Principle. There are 62 problems in *iTutor*: 30 problems about hydrostatic pressure and Pascal's Principle and 32 problems about Archimedes' Principle. The problems are arranged based on the difficulty level. The remedial notes are provided to students that do not pass Quiz 1.

The procedures to use the *iTutor* program are: (1) students use their username and password to log-in to *iTutor*, (2) students can choose the lesson and topic they need, (3) students complete the multiple-choice Quiz 1, (4) students receive the Quiz Report containing their score, learning assessment, understanding level of material per indicator, and a link to the next quiz, (5) students who do not pass Quiz 1 will undergo remedial instruction before continuing to Quiz 2 with the same difficulty as Quiz 1. Quiz 2 measures students' understanding after undergoing remedial education as well as their problem solving skills. (6) Students who pass Quiz 2 can continue to Quiz 3 for additional enrichment exercises.

iTutor was created with HTML 5, PHP 5, and CSS 3. The database management is arranged by MySQL application. The web hosting has 1 Gb capacity and 10 Gb bandwidth per month. When cPanel web hosting is defined, *iTutor* was accessed online through www.itutoronline.net, which is accessible from various web browsers. Fig. 1, Fig. 2, and Fig. 3 present a sample display of *iTutor*.



Figure 1. Quiz Display in the *iTutor* Program


| QUIZ REPORT 1 | | | | | |
|---|----------------------------------|---------------------------|---------------|---|---|
| Student Name | : Muhamad Rizal | Grade | | | |
| Number of Correct Answers | : 5 | 71 | | | |
| Number of Incorrect Answers | : 2 | | | | |
| Time | : 10 min 23 sec | | | | |
| Topic | : Archimedes' Principle | | | | |
|  | | | | | |
| Indicator | Number of Problems per Indicator | Number of Correct Answers | Status | Solution | Remedial |
| Describing Archimedes' Principle | 2 | 0 | GOOD | <input checked="" type="checkbox"/> see | <input checked="" type="checkbox"/> see |
| Explaining instruments or phenomena related with Archimedes' Principle | 1 | 0 | GOOD | <input checked="" type="checkbox"/> see | <input checked="" type="checkbox"/> see |
| Explaining Archimedes' principle to determine the situations of an object in a fluid | 2 | 0 | GOOD | <input checked="" type="checkbox"/> see | <input checked="" type="checkbox"/> see |
| Explaining buoyant force on any object in a fluid using Archimedes' principle | 2 | 0 | need remedial | <input checked="" type="checkbox"/> see | <input checked="" type="checkbox"/> see |
| Applying Archimedes' principle to determine physical quantities of an object in a fluid | 3 | 0 | need remedial | <input checked="" type="checkbox"/> see | <input checked="" type="checkbox"/> see |

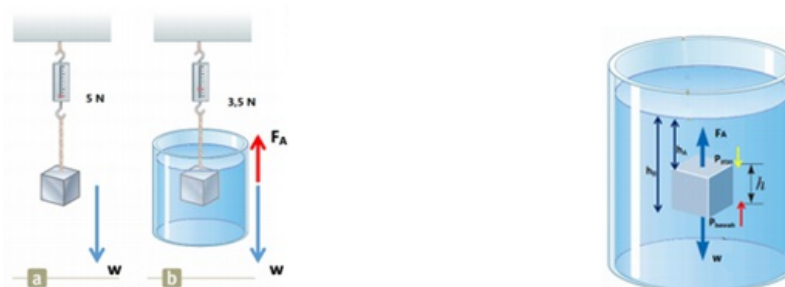
Figure 2. Student's Quiz Report in the iTutor Program

Describing Archimedes' Principle

Any object, partially or wholly immersed in a fluid, will experience a buoyant force. The magnitude of the buoyant force on that object always equals the weight of the fluid displaced by the object. This statement is then known as Archimedes' principle.

To better understand the concept of the buoyant force, consider a cube of solid material (a) suspended and then (b) completely immersed in a container of water (see figure). The reading on the spring scale after immersing the block in a container of water (3.5 N) is less than before (5 N). This is because the block experiences a buoyant force (F_A).

The net force in Fig. (a) is $\sum F = w = mg$ where w is the weight of the block; m is the mass of the block and g is acceleration due to gravity. On the other hand, the net force in Fig. (b) is $\sum F = w - F_A$, where F_A is the buoyant force or Archimedes Force.



To evaluate F_A , we do the following analysis.

We know that the pressure P_{bottom} at the bottom of the cube is greater than the pressure P_{top} at the top by amount $\rho_{\text{fluid}}gh$, where h is the height of the cube and ρ_{fluid} is the density of the fluid. The pressure at the bottom of the cube causes an upward force equal to $P_{\text{bottom}}A$, where A is the area of the bottom face. The pressure at the top of the cube causes a downward force equal to $P_{\text{top}}A$. The resultant of the two forces is the Archimedes force F_A , where

$$F_A = \rho_f g h_B A - \rho_f g h_A A = \rho_f g h A$$

As we can see that hA is nothing but the volume of the immersed cube V_c , therefore

$$F_A = \rho_f g V_c$$

Figure 3. Remedial Notes in the iTutor Program

Teachers can see the results of every student's quiz in the back end of the *iTutor* program. In the first lesson, students who received remedial instruction for Quiz 1 show a better score than when they took Quiz 2, with the average increasing of 25%. The average student score for Quiz 1 and Quiz 2 was 46 and 71, respectively. Fig. 4 and Fig. 5 show the students' scores for Quiz 1 and Quiz 2, respectively, in the first lesson and the second lesson, respectively.

Based on the data from the expert validation form, *iTutor* offers excellent feasibility for students and teachers in terms of product quality, particularly regarding the display. The program is also feasible in terms of its content, construction, language, and isomorphism. The trial field examination of *iTutor* was conducted by 17 students in grade X SMA BSS and 3 physics teachers. The quantitative analysis found that *iTutor* demonstrates excellent feasibility in terms of usage, ability, and added value. The *iTutor* program was thoroughly revised after its validation by experts. The review from expert lecturers was used to refine the product as well as the multiple-choice problems. Therefore, *iTutor* can be used to provide remedial learning to help students understand difficult physics concepts, such as fluid statics.

Trial Class Examination

The trial class examination focused on the topic of fluid statics. The *iTutor* program was provided to the experimental class as homework. Meanwhile, the control class was given paper-based problems. The implementation of the *iTutor* program for fluid statics learning in the experimental class began with an introduction of the *iTutor* program to the students. Every student was given an account to access *iTutor* so they could complete the quiz individually or in a group. The use of *iTutor* in the experimental class was conducted twice, i.e., in the first lesson on the subtopic of Hydrostatic Pressure and Pascal's Principle and in the second lesson on the subtopic of Archimedes' Principle.

Table 1 presents the percentage of students who passed the learning indicators and clearly indicates that remedial learning helps students achieve the learning objectives.

Table 1. Percentage of students who passed the indicators for Quiz 1 (before remedial learning) and Quiz 2 (after remedial learning) for the first lesson

| Indicator | Quiz | |
|--|------|--------|
| | 1 | Quiz 2 |
| Describing hydrostatic pressure equation (C2) | 56% | 75% |
| Explaining an instrument or phenomenon in correlation with hydrostatic pressure (C2) | 88% | 81% |
| Explaining hydrostatic pressure at different points in fluids (C2) | 14% | 70% |
| Applying the hydrostatic pressure equation in fluid statics (C3) | 71% | 71% |
| Applying the hydrostatic principle in fluid statics (C3) | 50% | 72% |
| Explaining an instrument or phenomenon as the application of Pascal's principle (C2) | 0% | 56% |
| Applying Pascal's Principle in a Hydraulic Jack (C3) | 66% | 72% |

iTutor also helps students earn better scores. Fig. 4 reveals the escalation of the students' scores for Quiz 1 (before remedial learning) and Quiz 2 (after remedial learning). In the first lesson, the students' scores increase due to the remedial learning.

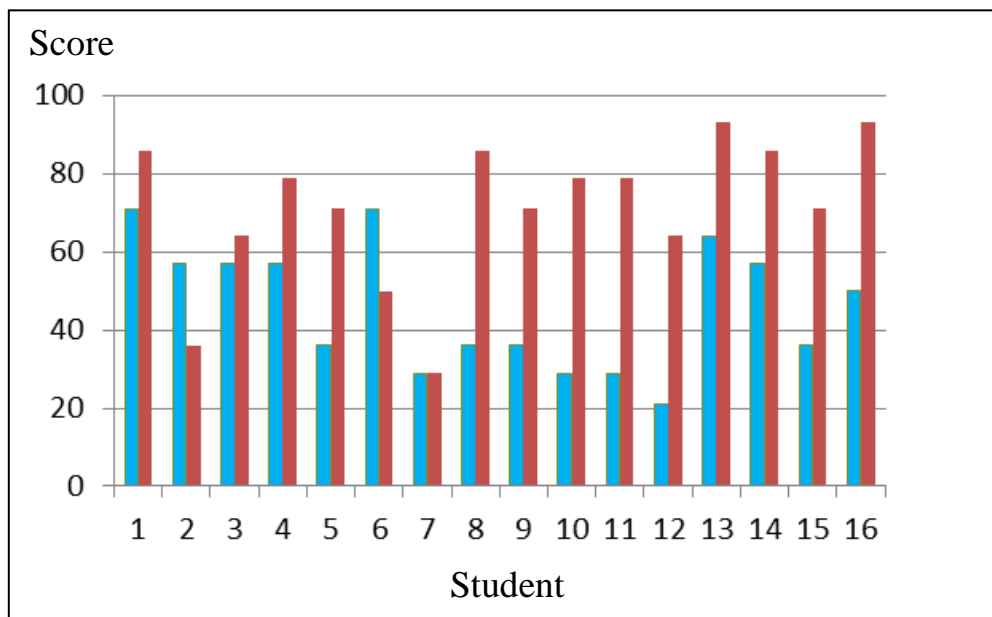


Figure 4. Student Scores in Lesson 1 after Taking Remedial Learning (Blue: Quiz 1 score, Red: Quiz 2 score)

Something similar also occurs during the second lesson. Students who did not attain the minimum score must receive remedial instruction. Afterward, the score increased 27% between Quiz 1 and Quiz 2. The average student scores in Quiz 1 and Quiz 2 were 53 and 81, respectively. Fig. 5 shows the diagram of students' score in Quiz 1 and Quiz 2 for the second lesson.

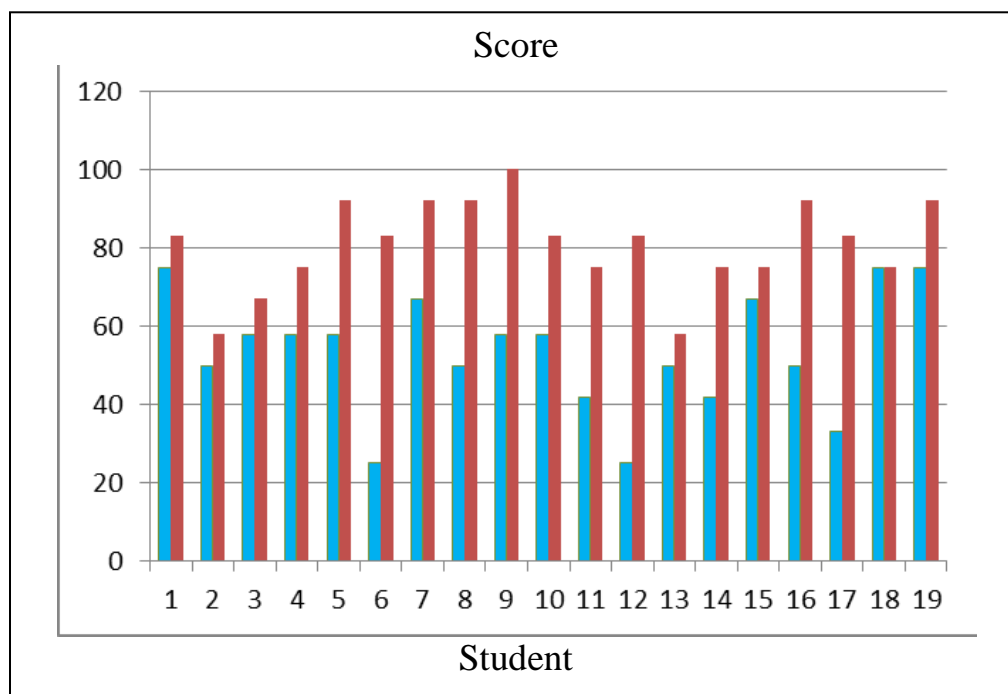


Figure 5. Diagram of student scores in Quiz 1 and Quiz 2 for the second lesson after remedial learning (Blue: Quiz 1 score, Red: Quiz 2 score)

Table 2 represents the percentage of students who receive remedial instruction for every indicator. The average score improvement from Quiz 1 (before remedial learning) to Quiz 2 (after remedial learning) in the second lesson is 30%.

Table 2. Percentage of students for Quiz 1 and 2 after remedial learning in the second lesson

| Indicator | Quiz 1 | Quiz 2 |
|---|--------|--------|
| Describing Archimedes' principle (C2) | 48% | 97% |
| Explaining an instrument or phenomenon in correlation with Archimedes' principle (C2) | 55% | 84% |
| Explaining Archimedes' principle to determine the state of a matter in fluid statics (C2) | 30% | 66% |
| Explaining buoyant force for any matter in fluid according to Archimedes' principle (C2) | 58% | 68% |
| Calculating buoyant force for matter in fluid by applying Archimedes' principle (C3) | 50% | 89% |
| Applying Archimedes' principle to determine physical quantities in a fluid (C3) | 69% | 81% |

A post-test in fluid statics made up of 25 multiple-choice problems focusing on hydrostatic pressure, Pascal's principle, and Archimedes' principle was then administered. Table 3 presents the t-test analysis result of the experiment and control groups' scores. There were 30 students in the experimental class and 27 students in the control class who completed the post-test. From the average post-test score, students who took *iTutor* received higher scores than those who did not. This can be inferred from the independent t-test results, in which the $t_{\text{calculation}}$ was 8.803, which was larger than t_{table} ($t_{\text{table}} = 2.005$) with a degree of freedom of 55 and significance of 0.05.

Table 3. Average student score in the experiment and control groups by means of t-test analysis

| | Experiment Group | Control Group |
|--------------------|------------------|---------------|
| Number of students | 30 | 27 |
| Average score | 81.60 | 74.52 |

DISCUSSION

The final product in this study was a web-based intelligent tutoring program (*iTutor*) for the remedial learning of the topic of fluid statics. Teachers can use this program to provide their students with opportunities to complete online assessments and receive remedial instruction, particularly regarding the topic of fluid statics. *iTutor* can identify students' challenges, provide timely feedback, and give appropriate tutorial instruction based on students' needs. This is similar to some of the research and development carried out by earlier researchers (Zang et al., 2008, Lin et al., 2007, Jong et al., 2004, Myneni and Narayanan, 2012, Pierce et al., 2001, Osman, 2010). This program is efficient for teachers, as students can access it after school.

In contrast to previous forms of online learning that provided various links, adaptive navigation space, information spaces, and collaborative spaces (Seridi-Bouchelaghem & Sellami, 2001) that supported active learning (Morgil & Ural, 2006), our *iTutor* focuses on the role of formative assessment and remedial learning. Once students access *iTutor*, they will receive a number of test items. Furthermore, the computer will automatically analyse the test results and provide feedback that students can use to see which topics are difficult for them. This information is necessary for students to evaluate their learning, as well as for physics instructors to evaluate the learning strategy. Before the next series of tests, students can access appropriate remedial learning tools. In other words, *iTutor* provides remedial services to students according to their needs.

From the research results, it can be inferred that *iTutor*, in general, is a very effective program. The advantages of *iTutor* include: (1) its accessibility via various web browsers and internet-connected devices; (2) quick feedback and quiz results, including a report with the score, time, completion of every indicator, and a link to solutions and remedial notes, all of which can be saved in a pdf format; (3) the written solutions are clear and complete, including animations to correct students' misunderstandings about fluid statics; (4) on the back end,

teachers can create problems and notes for remedial learning, manage course and meetings, add lessons and users, and view students' quiz reports; (5) there are 4 types of reports that can be saved in excel formats, i.e., students' scores, score per problem, percentage score per indicator, and answer of problem, all of which teachers can use to determine their students' abilities.

Using *iTutor* to learn fluid statics is effective in improving students' understanding via remedial learning. The average increase in student scores after taking remedial learning from Quiz 1 to Quiz 2 was 25% and 27% for the first and second lessons, respectively. Meanwhile, the average increase in students' mastery of the topics after remedial learning from Quiz 1 to Quiz 2 was 22% and 30% for the first meeting and second lessons, respectively. Hence, the quick feedback of remedial learning may increase students' understanding and comprehension of material. The average score of students who completed remedial learning with *iTutor* are higher than of those who did not. These results are consistent with those of previous studies (Klecker, 2007, Butz et al, 2004). In this study, the impact of *iTutor* can be evaluated based on concept mastery. It is, however, important to study the impact on other aspects, such as the meta-cognitive aspect (Shen & Liu, 2011).

CONCLUSION and IMPLICATIONS

Web-based intelligent tutoring (*iTutor*) has been successfully developed. *iTutor* focuses on the role of formative assessment and remedial learning. Validation and field-trial testing reveal that the *iTutor* program is feasible to apply. The examination results also indicate that *iTutor* can assist teachers in providing remedial instruction and can support students learning physics. According to the product development and implementation, the following suggestions can be proposed: (1) *iTutor* program can serve as homework for students, as students can use it individually after school without time or place limitations; (2) the report contains important information for students and teachers to evaluate students' challenges and achievement; (3) teachers can modify the problems, solutions, and remedial material in flash format for any desired topic; (4) a security system can be installed on *iTutor* to prevent a student from logging in with two different accounts; (5) the number of problems per indicator can also be increased.

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Developing Teaching Materials of Natural Product Chemistry to Increase Student's Life Skills

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Received: 04.01.2016

Revised: 20.10.2016

Accepted: 15.02.2017

The original language of article is English (v.14, n.2, June 2017, pp.27-41, doi: 10.12973/tused.10196a)

ABSTRACT

The research aimed to develop teaching materials of natural product chemistry (NPC) by conducting group investigation of cooperative learning model to increase students' life skills and to describe their feasibility. In this research, students' life skills include academic and social skills. Then, the intended feasibility includes three aspects—validity, practicality, and effectiveness aspect. The teaching materials (i.e., syllabus, lesson plan, students' books, and students' worksheets) accompanied by students' life skills observation sheets were developed using Research & Development methods as proposed by Borg and Gall. The teaching materials developed were used for the students of Chemistry Department, Universitas Negeri Surabaya, Indonesia. The developed materials were further assessed and validated by an expert (for validity aspect), and the implementation of the materials in the class were observed by a number of observers (for practicality and effectiveness aspects) and then analyzed quantitatively and described qualitatively. The findings of the research showed that the developed teaching materials of NPC were feasible because of their validity, practicality, and effectiveness. This means that the materials were valid according to the expert's judgments, were practical and effective when implemented in the NPC learning process, and were able to increase students' life skills.

Keywords: Feasibility, Natural Product Chemistry, Students' Life skills, Teaching Materials.

INTRODUCTION

Materials include textbooks, workbooks, cassettes, CD-ROMs, videos, photocopied handouts, newspapers, etc., and are used to impart knowledge (Tomlinson, 1998). Further, Tomlinson (2001 in Harsono, 2007) stated that "materials mean anything which are used to facilitate the learning process of students" and can be called as teaching materials. Teaching materials can be presented in the form of prints, live performances, on cassettes, CD-ROMs, DVDs, or via the internet. However, in this research, we focus on teaching materials that are presented in print form, including syllabus, lesson plan, students' books, students' worksheets, and students' life skills observation sheets.



Natural product chemistry (NPC) is the name of a course taken by students in the third year. In Indonesia, the course had been available mostly in higher education, including, in Chemistry Department, Universitas Negeri Surabaya, Indonesia. Almost all of Chemistry Department of higher education in Indonesia held in the course above. However, for this time, the course was taught without involving chemicals and other environmental sources as real objects in the classroom. Teaching materials of NPC arranged on the basis of field studies and using chemo-entrepreneurship (CEP) are not available in Indonesia. Therefore, we tried to prepare the materials (syllabus, lesson plan, students' books, students' worksheets, and students' life skills observation sheets) in this research.

Life skills have been defined by the World Health Organization as "abilities for adaptive and positive behavior that enable individuals to deal effectively with the demands and challenges of everyday life." They represent the psycho-social skills that determine valued behavior and include reflective skills, personal skills, and interpersonal skills. Life skills are thus distinctly different from physical or perceptual motor skills, as well as from livelihood skills, such as crafts, money management, and entrepreneurial skills (https://en.wikipedia.org/wiki/Life_skills-based_education).

Entrepreneurial skill is the ability of an individual to exploit an idea and create an enterprise (small or big) not only for personal gain but also for social and developmental gains (Olagunju, 2004 in Adeyemo, 2009). Entrepreneurship itself can be positively linked to economic growth by introducing new ideas, processes, products, services, and business opportunities (Mayhew *et al.*, 2012). Thus, we introduce a CEP approach, which is used in the learning process to use and maximize chemicals and other environmental sources as real objects. Chemical here means associated with chemical components contained in a plant and the functionality and usability of the plant itself to the interests and welfare of the community. In this case, students may learn to improve and give added value of the sources. Students can take advantage of a plant, e.g., mangosteenrind, that is known to contain a chemical mangostin as an antioxidant ingredient and/or for other bioactivity functions.

By using the CEP approach, students will get a hands-on experience in handling chemicals and environmental sources. Hence, the students are able to not only know, learn, and create how the sources can be treated to be new ideas, processes, and products that are useful and that have economic value but also grow their entrepreneurial skills. In this paper, we want to analyze students' entrepreneurial skills especially related to students' co-operation and communication skills that are part of social skills, besides academic skills.

Currently, in Indonesia, 70% out of 4,135,975 students opt for nonvocational subjects and only 30% opt for vocational subjects, and the university enrollment rate was only 29%. More than 71% or 2,055,580 students to general high school graduates back to the community without life skills (www.pdsp.kemdiknas.go.id). This means that they do not have the life skills to be truly ready for on-field activities. Therefore, a learning process that integrates the CEP approach to grow students' life skills should begin immediately, especially, in Indonesia.

Utomo *et al.* (2015) reported that the training of CEP approach integrated life skills is considered to be very appropriate to be administered to chemistry teachers. Related to this report, Paristiowati *et al.* (2014) have done a research that was conducted at SMAN 39 Jakarta, Indonesia. They informed that a student's cooperation and communication skills that are part of entrepreneurial skills can be improved through the implementation of the CEP approach. To improve a student's social skills, it can be facilitated by starting to use real objects or phenomena orientations available in our environments (Hardy, 2003). It meant that real objects or phenomena orientations can be used as a source and media to train students' social skills such as cooperation and communication skills. In this view, environments as material sources can be used as media of CEP or can be brought in the class to be studied by students. Material sources include herbs, processed products of herbal plant, preparation

process and packaging process. Therefore, an NPC lesson should be arranged and developed by partly involving environments. In this, material sources as media can be involved to arrange the teaching materials of NPC. The lesson can be provided in the class through an appropriate learning strategy. This can be achieved through a field study and using the CEP approach so that students can gain the required entrepreneurial skills.

Field studies should be done by teachers prior to preparing the teaching materials. By undergoing field studies, teachers will obtain many experiences so that they can overcome and look for a solution for handling the student's problems when students did a wrong activities deal with the results of field study. When conducting field studies, it was possible for students to do activities that are less precise, such as preparing the observation sheet for identification of the type and name of the herbs, mentioning its function as a traditional medicine, preparation for phytochemical test herbs, and others. To promote an achievement of students' life skills, a learning model that can be used to model and accelerate its syntax based on field study and CEP approach. That is, the syntax of the model should contain phases and activities of teachers and students who are oriented toward field study and CEP approach. The proposed learning model is the group investigation cooperative learning model (GI-CLM).

GI is one form of CLM. In GI, students form interest groups within which they plan and implement investigations and demonstrate the findings to the class in the form of group presentations (Ivy Geok-Chin Tan *et al.*, 2006). The teacher's general role is to make the students aware of resources that may be helpful while conducting the investigation (Zingaro, 2008). For this reason, we choose GI-CLM as stated by Slavin. Slavin (2005) stated that the syntax of the model included the following: 1) identify topics and segregate students into groups, 2) plan tasks that are learned, 3) perform the investigation, 4) prepare final reports, 5) present the reports, and 6) evaluate the final reports.

According to Joyce and Weil (Aunurrahman, 2010), GI-CLM possessed advantages that are able to facilitate academic research skills, social integration, and social learning process. The model made a condition in which students not only perform academic research but also perform social integration and a social learning process. As we have mentioned above that academic and social skills are a part of entrepreneurial skills, the skills should be trained in the learning model. For this reasons, this study focuses on developing teaching materials of NPC by conducting field studies and using the CEP approach. In general, the study can be illustrated by a framework as shown in Figure 1.

Developing teaching materials of NPC using GI-CLM to increase students' life skills has not been done yet. In addition, the materials developed by focusing more on field studies and by using the CEP approach had not also been done yet. The materials were developed by directly relating to real objects or phenomenon in our environments. By conducting field studies and using the CEP approach, students may obtain learning experiences regarding how a treatment process of natural sources may become useful products and added value. As a result, the learning process will be more interesting, joyful, and meaningful (Supartono, 2006 cited from Saptorini and Mursiti, 2007). One of the advantages of the learning that is developed on the basis of field studies and by using the CEP approach is that it enhances students' life skills. Students are able to use and maximize the natural sources (i.e., potential plants) become herbal medicines (Saptorini and Mursiti, 2007). In order to facilitate the learning mentioned above, it is required to develop teaching materials as mentioned above. In this paper, we only focus on students' life skills, in particular, **academic skills**, such as formulating a problem, preparing a hypothesis, designing a procedure, performing analyses, interpreting data, discussing, obtaining a conclusion, and presenting reports, and **social skills**, such as responsibility, collaboration, and accepting differences.

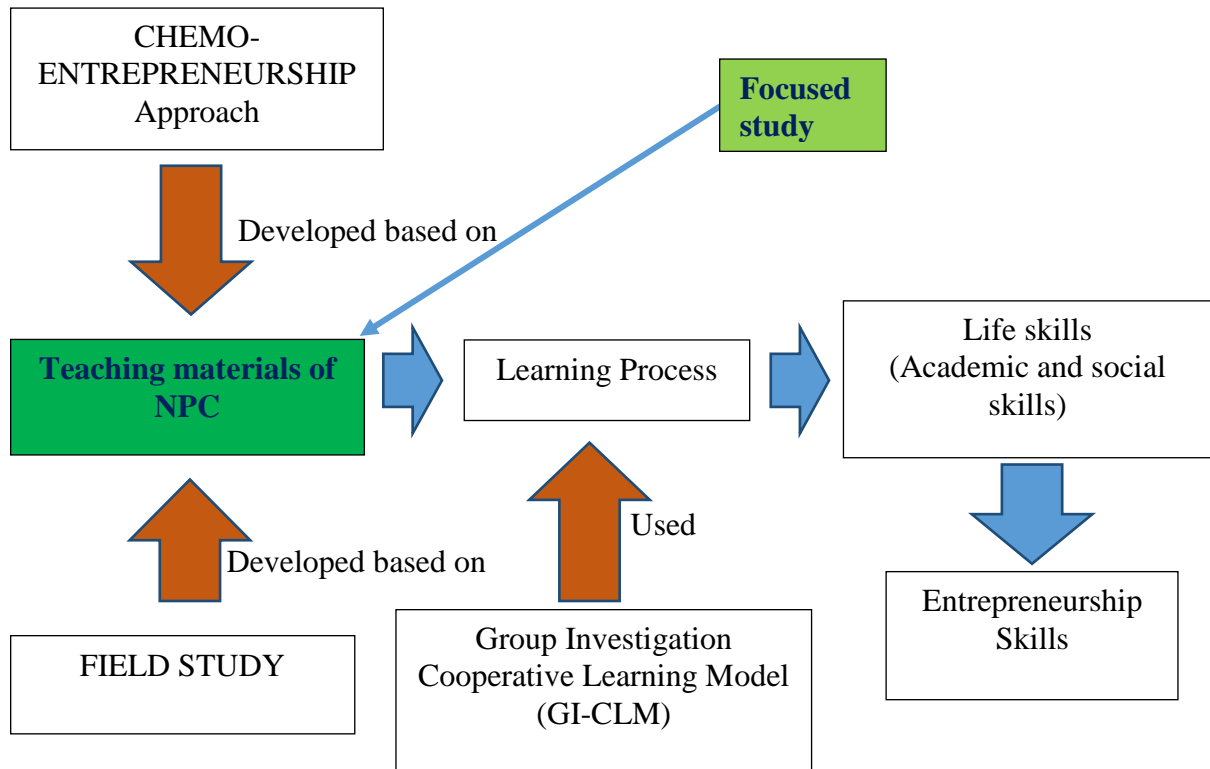


Figure 1. Theoretical framework to develop teaching materials of NPC using GI-CLM, to implement the materials, and to know their effects toward the students' life skills

The aim of the research is to know the feasibility of teaching materials developed on the basis of field studies and by using the CEP approach to increase students' life skills. According to Nieveen (1999), the feasibility of a teaching material should be tested from three aspects, i.e., validity, practicality, and effectiveness of the developed teaching materials. In this research, the validity of the materials will be theoretically determined on the basis of an expert's judgments, while the practicality of them will be answered by collecting data related to the implementation of the lesson plan and students' activities during the instructional process in the classroom. Then, the effectiveness of the materials will be examined by collecting data using the results of students' academic and social skill observation sheets during the learning process. The results and materials help the teachers in constructing students' academic skills of NPC and supporting students' social skills. We hope that the findings of the study could guide and help the lesson designers (teachers) in designing better teaching materials for teaching NPC.

METHODS

a. Teaching Materials' Development Procedures

The research was performed to know the feasibility of the teaching materials of NPC that were developed on the basis of field studies and by using the CEP approach through GI-CLM and to describe the results of implementation of the materials in the classroom. The research was done in three stages, i.e. 1) developing the materials, 2) doing validation and revision the materials, and 3) trying out the materials in the classroom.

At the first stage, the teaching materials were developed by referring to Research & Development (R&D) method (Borg and Gall, 1989). The R&D method consists of ten stages,

that are: (1) Study and Information Collecting, (2) Product Planning, (3) Preliminary Product Form developing, (4) Preliminary Field Testing, (5) Main Product Revision, (6) Main Field testing, (7) Operational Product Revision, (8) Operational Field Testing, (9) Final Product Revision, and (10) materials implementation. All of the first stages had been done and required corrections were revised to produce teaching materials of NPC. The teaching materials developed consist of syllabus, lesson plans (LP-01; -02; and -03), students' books (SB-01, -02, and -03), and students' worksheet (SW-01,-02, and -03). Ten stages to develop the materials can be explained as follows.

(1) Study and Information Collecting

At this stage, it has been carried out the literature study and field study. Literature study that had been conducted is to analyze the concepts and theories related to teaching materials of NPC especially the material support of Basic Competences and the selected indicators. The activity of field study supported by CEP approach is to identify, acquire, and collect information related to the early knowledge and descriptions of bioactive plants presented in the field. The next information are the results of phytochemical test of the plants, the recognition and understanding of the various separating techniques, and the knowledge and processing of traditional medicinal plants into herbal medicine. Stages of this research have largely been done in the first year (2014) of two years (2014-2015).

(2) Product Planning (teaching materials of NPC)

In this research, products proposed are NPC teaching materials. The entire information obtained from the first stage was used as materials to prepare and develop teaching materials of NPC. The plan of the development of teaching materials of NPC is initiated by preparing syllabus, lesson plan, students' book, and students' worksheet and is then followed by preparation of students' life skill observation sheets. The following are the components of students' books: 1) book title, 2) foreword, 3) a brief description of the course (includes competency standards, basic competences, indicators, and learning objectives) are taken from the syllabus and also laid in each chapter, 4) keywords, 5) chapter (matter), 6) exercises, 7) references, and appendix such as 8) student worksheet.

(3) Preliminary Product Form Development

Development of teaching materials of NPC, of course, preceded the development of the syllabus and lesson plan. Lesson plan is a guide that may be created by lecturers (researchers). The steps of the learning process should be well organized in a scenario of activities such that it easily facilitates and transfers matter to students. Moreover, a lesson plan is prepared for each meeting and comprises three meetings ($3 \times 3 \times 50$ min). Each meeting contains a different matter. Scenario learning activities developed by using GI-CLM as proposed by Sharan (in Supandi, 2005), includes the following: (1) lecturer divided the class into a heterogeneous group, (2) the lecturer explained the purpose of learning and task that should be performed, (3) lecturer summoned the head of each group to perform the material duties co-operatively, (4) each group discussed the matter co-operatively, (5) once completed, each group is represented its chairman or any member who presents the results of the discussion, (6) other groups can provide feedback on the results of the discussion, (7) lecturer gave a brief explanation (clarification and/or strengthening) in the event of an error or doubt and provided conclusions, and (8) procurement evaluation was conducted (test).

Moreover, some research instruments developed in this study include (1) validation sheets for teaching materials of NPC, (2) observation sheets of implementation of lesson plan, (3) observation sheet of students' activities, and (4) observation sheet of students' life skills.

The aspects observed to know students' life skills are (1) ability to read the material, to understand the essence of the material, and motivation to solve the problem; (2) ability to work in a group; (3) ability to communicate (included in the presentation) and respect the

opinion of people other; (4) capability of thinking and reasoning in performing stage process (compiling the final report of activity); and (5) skill and innovative thinking in making herbal medicinal products from medicinal plants as well as creativeness in designing the price of herbal medicinal products. All this work has produced a preliminary draft of NPC teaching materials (draft I).

(4) Preliminary Field Testing

Early trials of the product (NPC teaching materials) (draft I) are conducted to validate the product. That is, teaching materials of NPC that are developed on the basis of field studies and by using the CEP approach is further validated theoretically (theoretical validation: construction and contents) (aspect of **validity**), namely, by asking for feedback/comments and assessment of experts who strongly understand the field or course material of NPC with minimal academic qualifications as doctor and/or masters who are studying education doctoral program.

(5) Main Product Revision

Based on the feedback/comments of experts in the fourth stage, researchers revise teaching materials of NPC (draft I). The revised draft I is the teaching materials of NPC (draft II).

(6) Main Field Testing

NPC teaching materials (draft II) were validated in terms of construction and contents and then were tested to assess the feasibility of NPC teaching materials from the aspect of **practicality** (empirical validation). The test may be carried out and determined by some research instruments, i.e., (1) observation sheets of implementation of lesson plan, (2) observation sheet of students' activities, and (3) observation sheet of students' life skills.

(7) Operational Product Revision

After teaching materials of NPC are tested, the next step is to revise the teaching materials of NPC (draft II). The stage produces teaching materials of NPC (Draft III).

(8) Field Operational Testing

NPC teaching materials (draft III) are further tested to assess the feasibility of teaching materials (empirical validation) from the aspect of **effectiveness**. The test can be executed after teaching materials of NPC have been compiled and prepared.

(9) Final Product Revision

The teaching materials of NPC are further refined on the basis of the results above to always learn, analyze, and interpret feedback/comments and suggestions. These activities will lead to the acquisition of NPC teaching materials that are more complete, perfect, and readily disseminated in the field (the class) that is greater.

(10) Teaching Material Implementing

Implementation of teaching materials of NPC had been conducted in the classroom within a specified period (3 meetings). When implementing the materials in the class, it is necessary to prepare some research instruments as mentioned above.

At the second stage, all of teaching materials of NPC are validated by an expert's judgments by using a validation sheet. After the materials are stated to be valid by the expert, they will be implemented in the classroom to confirm their practicality and effectiveness.

At the last stage, the materials that are valid were further tested in the classroom. This was followed by data collection by using three data collection tools: (1) observation sheet about lesson plan implementation, (2) observation sheet about students' activities, and (3) observation sheet about students' life skills. All of these tools had been validated by experts before being used to collect data needed. All of collected data was then analyzed quantitatively and described qualitatively.

The learning activities in the classroom were observed by three observers. The observers monitored the students' activities and students' life skills (**academic and social skills**) and also gave scores using observation sheets based on their rubrics.

b. Participants

Third year students registered in the Chemistry Department, Universitas Negeri Surabaya, Indonesia, were required to enroll for a NPC lesson. There are two parallel classes, class A and class B, comprising 25 students each (totally 50 students). All students are treated to be participants.

c. Data Collection Tools

This study used four data collection tools as mentioned above that will be needed to know the feasibility of the teaching materials of NPC: (1) observation sheet about lesson plan implementation, (2) observation sheet about students' activities, (3) observation sheet about students' life skills, and (4) validation sheet for an experts' judgement.

d. Validity and Reliability of Instruments

Before being used as data collection tools, the validity and reliability of the instruments should be determined as explained below.

1) Validity of Instruments

There are four types of validity to assess an instrument: 1) content validity, 2) face validity, 3) concurrent validity, and 4) construct validity. Validity refers to what is tested and how well this corresponds with the behavior. Validity, however, is not a simple concept, and various forms of it are identified according to the basis of the judgement of validity. Evidence relating to the **content validity** of an instrument would result from comparing the content assessed with the content of a curriculum that it was intended to assess. **Face validity** is based on expert judgement of what an assessment appears to assess, while **predictive validity** is the extent to which an assessment reflects an intended future performance. **Concurrent validity** is derived from the correlation of the outcomes of one assessment procedure with another that is assumed to assess the same knowledge or skill. **Construct validity** is a judgement of how well the assessment calls upon the knowledge and skills or other constructs that are supposedly assessed. The validity requires a clear definition of the domain being assessed and evidence that, in the assessment process, the intended skills and knowledge are used by the learners (Harlen, 2000). In the research, we only use two types of validity that are **content and construct validities** to assess the instruments including teaching materials of NPC, with category as shown in Table 1.

Table 1. Validation assessment category for the instruments (also teaching material of NPC)

| Average Scores | Category |
|----------------|--------------|
| >3.6 | Strong valid |
| 2.8–3.6 | Valid |
| 1.9–2,7 | Enough |
| 1.0–1.8 | Invalid |

Source: Adapted from Ratumanan (2006)

Based on the category as mentioned in Table 1 above, the materials developed on the basis of field studies and the CEP approach by using GI-CLM are called to be valid if all of components of the instruments including teaching material of NPC were assessed by validators with an average score of ≥ 2.51 .

2) Reliability of Instruments

As mentioned above, there are four data collection tools (instruments) that will be used in the study. However, there are only two instruments whose reliability will be

determined, namely (1) observation sheet about lesson plan implementation and (2) observation sheet about students' activities. Their reliability can be known by using the equation below that is called "percentage of agreement."

$$\text{Percentage of agreement} = \left[1 - \frac{A-B}{A+B} \right] \times 100\%$$

where A is the frequency aspect of the activity observed by observers who give high frequency and B is the frequency aspect of the activity observed by an observer who provides low frequency

The tools that had been prepared can be called to be reliable if they gave percentage of agreement $\geq 75\%$ (Borich, 1994).

e. Data Analysis Techniques

In this study, data analysis techniques used include (1) analysis of the results of validation of NPC teaching materials and instruments, (2) analysis of the implementation of NPC lesson plan, (3) analysis of students' activities in the learning process, and (4) analysis of students' life skills. These will be explained as follows.

(1) Analysis of the Result of Validation of NPC Teaching Materials and Instruments

NPC teaching materials (syllabus, lesson plan, student' books, and students' worksheet, and keys) and research instruments ("data collection tools") had been prepared. The validation of NPC teaching materials and research instruments can be conducted by validators (two persons) by means of providing a score from 1 to 4. Validators are also asked to give advice and comments (if any) toward the materials and instruments. The scores given are then analyzed to determine average scores. From the average scores, their category can be established, as presented in Table 1. The teaching materials of NPC and instruments that have been validated will be revised in accordance with the advices and comments from a validator to obtain the materials and instruments that qualify and are eligible for use in the next trial.

(2) Analysis of the Implementation of NPC Lesson Plan

When the NPC lesson plan was implemented in the classroom, it was observed by three observers by means of providing a score from 1 to 4. Observers are also asked to give advice and comments (if any) toward the implementation of the lesson plan. The scores given are then analyzed to determine the average scores. From the average scores, their category can be established, as presented in Table 2. Two observers at the trial stage for three meetings use the same instrument to observe the same variables. Assessment category for implementation of Lesson Plan can be shown as in Table 2.

Table 2. Assessment category of implementation of NPC lesson plan

| Average Scores | Category |
|----------------|-----------|
| >3.6 | Very good |
| 2.8–3.6 | Good |
| 1.9–2.7 | Enough |
| 1.0–1.8 | Not good |

Source: Adapted from Ratumanan (2006)

Agreement between the two observers who had given judgment on the implementation of the lesson plan will be calculated by the percentage of the agreement technique. Both analysts were asked to rate according to observation results that were tested.

(3) Analysis of Students' Activities in the Learning Process

Agreement between the two observers who had given judgment on students' activity instruments during the learning process will be calculated by the percentage of agreement technique. Agreement between the two observers who had given judgments on students' activity for three meetings will be calculated by the percentage of agreement technique. Both analysts were asked to rate according to observation results that were tested.

(4) Analysis of Students' Life Skills

Students' life skills (academic and social skills) are analyzed on the basis of assessment results by observers by using a given assessment rubric. Assessment category for students' life skills in the learning process can be shown as in Table 3.

Table 3. *Assessment Category of Students' Life Skills in Learning Process*

| Average Scores | Category |
|----------------|-----------|
| 3.56–4.00 | Very good |
| 3.00–3.55 | Good |
| 2.56–2.99 | Enough |
| 1.00–2.55 | Not good |

Source: Adapted from Ratumanan (2006)

Students are said to possess the mastery of life skills competences if the profile of their life skill lied on a minimal category of **good (3.00–3.55)**.

RESULTS AND DISCUSSION

RESULTS

The feasibility of a teaching material is determined by three aspects: 1) validity, 2) practicality, and 3) effectiveness (Nieveen, 1999). Three aspects of developed teaching materials of NPC that are obtained can be reported as follows.

a. The Validity of Developed Teaching Materials of NPC and Instruments

The validity of developed teaching materials of NPC was assessed by experts' judgments (two persons). According to the experts, all the teaching materials developed are valid. The average score that was given by the experts for syllabus is 3.80; for lesson plan LP-01, LP-02, and LP-03 are 3.86, 3.88, and 3.88; for students' book SB-01, SB-02, and SB-03 are 3.80, 3.83, and 3.85; for students' worksheet SW-01, SW-02, and SW-03 are 3.83, 3.85, and 3.83. Then, the average score that was given by the experts for observation sheets of academic skills for two meetings are 3.92 and 3.92. While the average score given for observation sheets of social skills for three meetings are 3.95, 3.95, and 4.00. As the average score of the materials and instruments given by experts is more than 3.60 (≥ 3.60), so the materials can be categorized to be strong valid.

b. Practicality of Developed Teaching Materials of NPC

Practicality of developed teaching materials of NPC can be seen from the observation results after the implementation of the lesson plan and students' activity during the learning process. The observation results of both can be explained as follows.

1) The Implementation of Lesson Plans of NPC

The implementation of lesson plans of NPC (LP-01, LP-02, and LP-03) during three meetings had been observed by three observers. The average score that was given by the observers for implementations of LP-01, LP-02, and LP-03 are 3.50 (good category); 3.50 (good category); and 3.87 (very good category), respectively. The percentage of

agreements that was given for LP-01, LP-02, and LP-03 are 82.59%; 88.57%; and 96.03%, respectively. It seems that the average score and percentage of agreement of lesson plan increased when implemented during three meetings.

2) Students' Activities during Learning Process

During learning process for the three meetings (meeting 1, 2, and 3), students' activities was observed by the same observers (three persons). The average of percentage (%) for students' activities was represented in Table 4. As shown in Table 4, it seems that predominant students' activities in learning process are 1) browsing the internet, 2) working in groups, and 3) presenting their works and have average scores of 23.19%, 21.62%, and 11.76%, respectively. Therefore, the lesson plans developed by NPC had maximized the students' activities especially for three activities as mentioned above.

Table 4. The results of analyzed data of students activities during three meetings

| No | Students Activities | Percentage of Students' Activity (%) | | | Average of Percentage (%) |
|--------------|--|--------------------------------------|------------|------------|---------------------------|
| | | Meeting 1 | Meeting 2 | Meeting 3 | |
| 1 | Paying attention to the lecturer explanation | 8.96 | 7.01 | 8.93 | 8.30 |
| 2 | Reading student books | 8.96 | 7.90 | 8.04 | 8.30 |
| 3 | Preparing student worksheets | 16.99 | 9.65 | 9.38 | 12.01 |
| 4 | Browsing the internet | 15.57 | 26.32 | 27.68 | 23.19 |
| 5 | Working in a group | 18.87 | 24.12 | 21.87 | 21.62 |
| 6 | Presenting their work | 12.27 | 10.96 | 12.05 | 11.76 |
| 7 | Asking or giving comments | 8.96 | 4.83 | 4.92 | 6.24 |
| 8 | Arguing | 7.54 | 7.01 | 6.70 | 7.08 |
| 9 | Others | 1.88 | 2.20 | 0.44 | 1.51 |
| Total | | 100 | 100 | 100 | 100 |

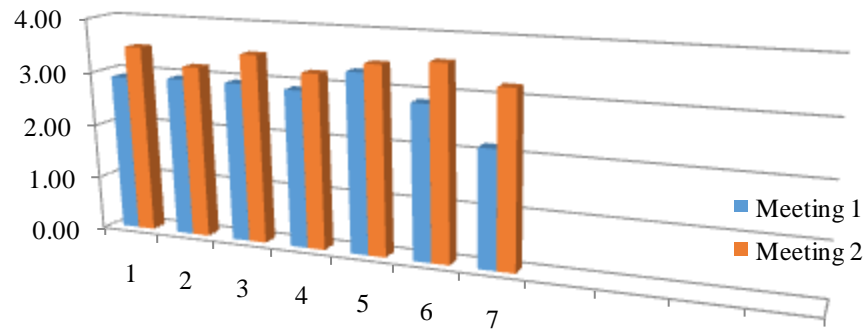
c. Effectiveness of Teaching Materials of NPC

The effectiveness of the developed teaching materials of NPC was also confirmed by the data that were collected after trying out materials in the classroom. There were at least two data that were able to confirm the effectiveness of the developed teaching material, i.e., 1) the data related to academic skills and 2) the data related to social skills. These data entirely confirmed that the developed teaching materials were effective to be implemented in the classroom.

1) Students' Life Skills (Academic Skills)

In this case, students' life skills (academic skills) that were observed included 1) formulating a problem, 2) constructing a hypothesis, 3) designing a procedure, 4) conducting analyses and data interpretation, 5) discussing, 6) obtaining conclusions, and 7) presenting reports. The analyzed data during two meetings were resulted as seen in Figure 2 below.

As presented in Figure 2, academic skills (such as formulating a problem, constructing a hypothesis, designing a procedure, conducting analyses and data interpretation, discussing, obtaining conclusions, and presenting reports.) had been represented by students at the meetings 1 and 2 with average scores of 3.05 and 3.50, respectively.



Note:

1) formulating a problem, 2) constructing a hypothesis, 3) designing a procedure, 4) conducting analyses and data interpretation, 5) discussing, 6) obtaining conclusions, and 7) presenting reports.

Figure 2. Diagram of Analyzed Data of Academic Life Skills at Meeting 1 and 2

It seems that the average score for students' academic skills are categorized to be good (3.00–3.55). Therefore, the teaching materials of NPC were developed on the basis of field studies and by using the CEP approach and their implementation in the classroom, we were able to increase students' academic skills because there is an increase of average score of them from 3.05 to 3.50 for two meetings.

2) Students' Life Skills (Social Skills)

Students' social skills were observed by three observers. Social skills observed included responsibility, collaboration, and accepting differences by using an observation sheet of social skills and obtained average score of them as shown in Figure 3 below.

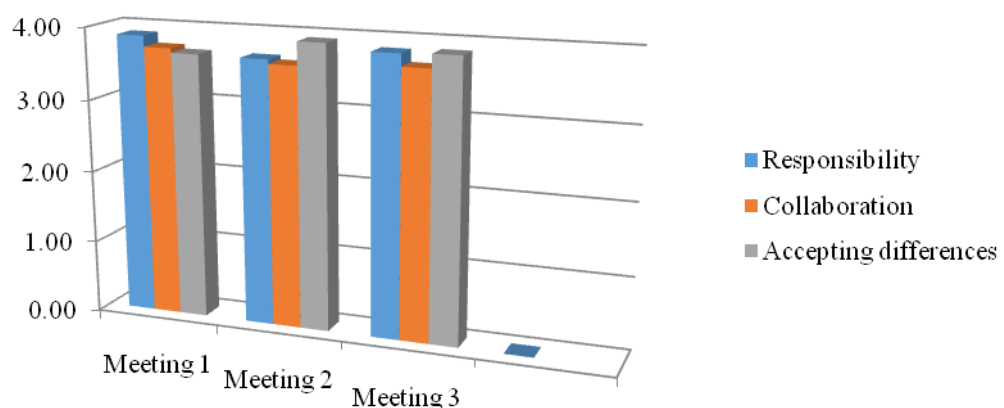


Figure 3. Diagram of Analyzed Data of Social Skills at Meeting 1, 2, and 3

As shown in Figure 3, it was reported that average scores of responsibility are 3.88; 3.66; and 3.84, collaborations are 3.74; 3.60; and 3.84, and accepting differences are 3.67; 3.92; and 3.86 with their modus 3.80; 3.82; and 3.84, respectively, for meetings 1, 2, and 3. It seems that the average score for students' social skills are categorized to be very good (≥ 3.60). Therefore, the teaching materials of NPC developed on the basis of field studies and by using the CEP approach and their implementation in the classroom were able to

increase students' social skills because there is an increase of average modulus of them from 3.80; 3.82 to 3.84 for three meetings.

DISCUSSION

As mentioned above that the aims of the research were to develop teaching materials of NPC by conducting group investigation of cooperative learning model (GI-CLM) and to describe their feasibility. In this case, teaching materials of NPC had been developed. The teaching materials were developed using research & development methods proposed by Borg and Gall. After the materials were developed, the next step was to describe their feasibility. According to Nieveen (1999), the feasibility of the teaching materials developed should refer to three aspects, i.e. validity, practicality, and effectiveness.

Firstly, the validity of the materials and research instruments developed had been stated to be strong theoretically by expert's appraisal. This is supported by the average score for the materials and instruments given by experts to be more than 3.60. Therefore, the materials and instruments were ready to be implemented in the classroom.

Secondly, the practicality of the materials can be shown by two data, namely (1) data related to lesson plan implementation and (2) data related to students' activities during learning process. The average score and percentage of agreement that was given by the observers for implementations of LP-01, LP-02, and LP-03 were categorized to be good (3.00–3.55) and very good (≥ 3.56). Therefore, it can be established that the materials can be practice to be implemented in the classroom.

The third, the effectiveness of the materials can be confirmed by two data that are (1) data related to students' academic skills obtained after learning process and (2) data related to students' social skills gained during learning process. As reported above that the students' academic skills had been represented by students at the meetings 1 and 2 with average scores of 3.05 and 3.50, respectively. As their academic skills lay in the good category (3.00–3.55), students can be said to possess the mastery of life skills competencies. Furthermore, the average scores of students' social skills at three meetings for responsibility are 3.88, 3.66, and 3.84; collaborations are 3.74, 3.60, and 3.84; and accepting differences are 3.67, 3.92, and 3.86 with their modulus 3.80, 3.82, and 3.84, respectively. It seems that the average score for students' social skills are categorized to be very good (≥ 3.60). Therefore, the teaching materials of NPC developed on the basis of field studies and by using the CEP approach and their implementation in the classroom were able to increase students' social skills because there is an increase of average modulus of them to 3.80, 3.82, and 3.84 for three meetings.

In Indonesia, some researches related to development of teaching materials with various topics/matters and oriented on certain learning models/methods/approaches had mostly been conducted to be used in elementary schools until higher education. In addition, a research related to development of teaching materials of certain topics/matters using the CEP approach have also been partly done. However, research related to development of teaching materials of NPC using GI-CLM focused on field study and CEP approach had not been studied yet.

The following are some researches that are relevant with this purposed research such as researches conducted by: **1)** Sumarti (2008) reported that Practice of General Chemistry Lesson at Study Program of Chemistry Education, Universitas Negeri Semarang, Middle Java, Indonesia, was able to increase entrepreneurship motivation for students' chemistry education, **2)** Mursitiet *al.* (2006), and **3)** Saptorini and Mursiti (2007), concluded that the implementation of model and teaching materials using CEP and *home industry* approaches as CET media through field observation can increase entrepreneurial skills and students' learning outcomes on Terpenoid and Alkaloid Topics, **4)** Supartono (2006) with title "Increasing Students' Creativities in Chemistry Learning Using CEP Approach," declaring that

implementation of Chemistry learning model using CEP approach can improve students' creativities, 5) Sumartiet *al.* (2014), stated that learning tools for chemoentrepreneurship-based hydrocarbon and petroleum was valid and effective in increasing the soft skills and interest in entrepreneurship of X-2 Graders of SMA PGRI, Jepara, Middle Java, Indonesia, 6) Kadarwati *et al.* (2010), concluded that the learning method using the CEP approach on Chemistry-Physics 5 Lesson possess an important role in being easy to understand the lesson, 7) Kusuma and Siadi (2010) study—"Developing Materials (Students' Books) of Chemistry oriented on CEP to increase Students' learning outcome and life skills"—declared that the materials of Chemistry based on CEP approach developed were valid and effective in increasing students' learning outcome and life skills, and 8) Adlimet *al.* (2014), reported that the research integrating entrepreneurial practice in biotechnology lesson is reasonable since some of traditional home-made biotechnology products have been commercially available in local market. Those products include yeast, soybean fermentation with Indonesian name as "tempe," "tahu or tofu," "tauco," rice, or cassava fermentation ("tape"). From this, students could learn to improve the value addition of the commodities by making a better packaging, new tastes, a new appearance, or through a new marketing system. Thus, teaching materials developed referring to field study and CEP approach that has been declared to be valid when implemented in the classroom will provide a change to an increase in life skills.

In other words, the teaching materials of NPC lesson that are stated to be valid according to expert's appraisal had been proven to be effective to be implemented in the NPC learning process and be able to increase the students' life skills.

CONCLUSION

The teaching materials of NPC developed on the basis of field studies and by using a chemo-entrepreneurship (CEP) approach with GI-CLM were valid according to experts' opinion. In relation with the implementation of the materials, it can be reported that (1) the developed lesson plan could be implemented well in the classroom and (2) the students were highly engaged in GI model of environmental instruction so they were practice. Then, the effectiveness of the materials can be considered by two aspects, i.e. students' academic and social skills. The results reported that the students' life skills showed significantly improvement during learning process (at meeting 1 and 2 for academic skills and at meeting 1, 2 and 3 for social skills). Referring to the aims of the research supported by the results and discussion, it can be concluded that the teaching materials of NPC arranged based on field study and CEP approach using GI-CLM are feasible.

Acknowledgments

This paper is partly funded by *Islamic Development Bank* in collaboration with Decentralization Program on Penelitian Unggulan Perguruan Tinggi-Scheme, Directorate of Research and Community Service (DP2M), General Directorate of Higher Education, through LoA of Rector of Universitas Negeri Surabaya, No. 122/UN38/HK/LT/2015, 17 February 2015. We are very grateful for the funding assistance.

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Developing Energy Systems Engineering Students' Perceptions of Renewable Energy for Sustainable Future

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Received: 16.02.2016

Revised: 01.12.2016

Accepted: 15.02.2017

The original language of article is English (v.14, n.2, June 2017, pp. 41-51, doi: 10.12973/tused.10197a)

ABSTRACT

The main purpose of this study is to describe engineering students' perceptions about renewable energy. The paper focuses what the engineering students' know about renewable energy and developing their understanding on it. To determine students' pre- and post-perceptions about renewable energy, firstly, the questionnaire was developed by the researcher. After conducting the questionnaire, the courses and seminar were prepared. Then, the differences of percentages between pre- and post perceptions were identified. This study found that although the students were in Energy System Engineering Department, they still had many misconceptions about renewable energy. After the course prepared by researcher many students handled their misconceptions and developed their knowledge about renewable energy. This study has demonstrated that as the course took place, the perceptions, and misconceptions of students about renewable energy changed. It also recommended that if the single course can achieve the changes of perceptions and misconceptions of students, consistent changes might be succeeded by curriculum. The learning outcomes of the students showed that the course fits exactly for fulfilling future necessities for the education of students in sustainable topics.

Keywords- Renewable energy, Sustainability, Engineering students, Students' perceptions

INTRODUCTION

Sustainability has actually many aspects such as economic, ecological, and social (Emanuel and Adams, 2010). The "sustainable development" term was originally declared by the United Nations in Agenda 21 (Agenda 21, 1992). Actually, sustainable development term refers "durable development" other than English language and it has "durable", "long-term" or "continued" meanings among others (Leal Filho, 2000). For this development, the qualified people are a necessity. Thus, universities and schools have tried to achieve an embedding sustainability into their education systems. Also, a great number of studies have portrayed a variety of ways to carrying out education for sustainable development by courses or revising curriculum in last decade (Lozano Garcia *et al.*, 2006; Sterling and Thomas, 2006). Especially, the function of universities in this concept is very important not only because they



have conducted many researches about sustainability but also they educate qualified people which contribute to a sustainable future (Barth and Rieckmann, 2012).

In the recent years, Education for Sustainable Development (ESD) has become important in all levels of education. There are strong political and social will to accommodate ESD to education especially in higher education levels. Its severity increases with the declaration of United Nations namely *Decade of Education for Sustainable Development* from 2005 to 2014. Also, the year 2012 was selected as *International Year of Sustainable Energy*. (Pullen and Brinkert, 2014). Internationally, there is a huge attention on renewable energy. Energy is necessity for all basic living needs. However, it is fact that fossil fuels will end in the near future and energy costs increase rapidly. Thus, the solution is that reproductive use of existing sources and recycling energy achieved by the renewable energy.

Engineering professionals are forced to perform engineering more sustainably (WFEO, 1999). Therefore, engineering academics have tried to educate their students about sustainability especially sustainable energy a significant part of sustainable development (Carew and Mitchell, 2002). At this point, the significant question is that how they might achieve to teach their students in this aspect. For this aim, the first thing is what the students know and understand about renewable energy. It is needed to be clear what the renewable energy means or what the students think about it. While the renewable energy receives a lot of attention from the all parts of social life, there is still much confusion on it. Hence, it is important to know and develop engineering students' conceptions about renewable energy. The students' perceptions of sustainability were determined in last decades (Zeegers and Clark, 2014, Emanuel and Adams, 2011, Yumurtaci, 2012). Zeegers and Clark mainly focused on developing students' understanding of sustainability. For this reason, they designed and prepared a tertiary course and seminar in sustainability. The survey was used to determine students' perceptions about sustainability as pre- and post-test in the course. They found that interesting in sustainable development was complex. Also, they showed that if the students can act active role in their learning, they could establish a more balanced view on sustainability. They proof that the change about perspectives needed a longitudinal study.

As to Emanuel and Adams, they compared the college students in Alabama and Hawaii based on three questions: " 1) Are students concerned about the present/future? 2) What do students know about sustainability? 3) Who is responsible for sustainability?" They found that students were interested in wasteful consumption and pollution in two colleges. The students were same in terms of their self-assessed knowledge about sustainability. Also, they were same in their views about who is responsible for sustainability. However, the majority of students in Hawaii declared that they were volunteer to join for sustainable practices.

Numerous studies have been reported about what engineering students know about sustainability and renewable energy (Carew and Mitchell, 2002, Kagawa, 2007, Yumurtaci, 2012, Zeegers and Clark, 2014). However, very little has been prepared courses to train students to deal with their misconceptions. The misconceptions are so important and the first step for achievement an effective concept teaching is to find out students' misconceptions that may differ from the scientific ones (Unal, S., 2010, Taber, K.S., 2011).

This present study will thus focuses on perceptions of students about renewable energy. An enough understanding of the concept of renewable energy is a first and vital step for educating qualified engineering people for sustainable future.

The study

The main purpose of this study was to describe engineering students' perceptions about renewable energy. It was planned to contribute to literature that has some deficiency about research related to students' perceptions about sustainability and particularly renewable

energy (Carew and Mitchell, 2002, Kagawa, 2007, Yumurtaci, 2012, Zeegers and Clark, 2014).

The paper focuses what the engineering students' know about renewable energy and developing their understanding on it. For this reason, the questionnaire was developed to determine their initial perceptions of renewable energy. Then, the courses and seminar were prepared to improve their perceptions of renewable energy.

Research Questions

The main research questions were about students' conceptions about renewable energy before and after attending courses. The questions were below as:

Q1: What do the students know about renewable energy?

Q2: Did students' perceptions about renewable energy change by the courses?

METHODS

To determine students' pre- and post-perceptions about renewable energy, firstly, the questionnaire was developed by the researcher. After conducting the questionnaire, the courses and seminar were prepared. Then, the differences of percentages between pre- and post perceptions were identified.

Questionnaire

The 20-item Renewable Energy Awareness Questionnaire was developed based on (1) the literature on misconceptions of renewable energy, (2) interviews with students that include misconceptions about renewable energy.

The items included *knowledge about renewable energy* (items 1,2,4,6, 8 and 10), *knowledge about solar energy* (items 3,7,11,13, and 16), *renewable energy in Turkey* (items 5,9,12,14, and 15), and *perceptions about their department and themselves* (items 17,18,19, and 20). The Cronbach coefficient alpha was 0.62.

The students responded on a Likert-type scale from (1) strongly agree, (2) agree, (3) undecided (4) disagree, and (5) strongly disagree options. Before the conducting study, the questionnaire was piloted with 102 engineering students in state university. With the pilot study, some corrections to the questionnaire were made based on these insights and students' responses. It was carried out before and after the course and took nearly 20 minutes.

Samples

The Questionnaire was applied to undergraduate energy systems engineering students' during fall semester of 2014. The Questionnaire was distributed all freshmen and juniors students in this department. Data were observed from a total of 89 students in a state university in Giresun. Participants were volunteers. The majority of the students were freshmen (%82) and 18 percent of the students were juniors. The greater number of students (79.8%) was male and the rest of the students (20.2%) were female. The participants' ages ranged from 18 to 22 years old.

The course

The Renewable Energy with All Aspects is an undergraduate course, which focuses on renewable energy in terms of basic knowledge about it and energy policy in Turkey and world. It includes lectures that namely as follows:

1. Renewable Energy and its sources in Turkey and the world
2. The benefits of Renewable Energy?

- 3 Solar energy and the researches and applications of solar energy in Turkey
4. The renewable energy and climate change
5. The policy of Renewable Energy in Turkey and the world
6. Movie about climate change and Renewable Energy
7. Discussion seminar on Renewable Energy

The course was developed and carried out by the researcher in collaboration with the Department of Energy Systems Engineering in Giresun University, Turkey. The purpose was to arrange an undergraduate course that included teaching methods to give knowledge about renewable energy and policy to engineering students.

The course was implemented as an intensive one-week course. The fundamental elements of the course were lectures given by academicians from the Department of Energy Systems Engineering. The lecturers explained their topics in a greater detailed and got and answered students' questions about this topic. After ending lectures, the movie about climate change and Renewable Energy was watched by the students. Then, discussion seminar was organized and implemented by the researcher. In this discussion seminar, students not only share their knowledge about renewable energy but also discuss their ideas about energy policy of Turkey.

Course Evaluation

The course was evaluated on two standards as follows:

1. The perceptions of the students were evaluated by the Renewable Energy Awareness Questionnaire, which was implemented as a pre-, and post-test.
2. Students' ideas and satisfaction were determined by the interviews that were carried out after the questionnaire and include concepts of course and their learning outcomes.

Interviews

Semi-structured individual interviews were conducted to make sure of satisfaction of the students about the course. During the interviews, students were asked to explain what they think about the course. In the study, 10 students were interviewed after the questionnaire in the class environment. These students were selected randomly. Each interview continued for approximately 10 minutes and all interviews were recorded on audiotape. The questions were presented as follows:

1. What do you think about the course?
2. Did you believe whether the course is well design or it has some deficiencies?

RESULTS

Perceptions of the Students

Renewable Energy Awareness Questionnaire was carried out to determine the perceptions of the students as a pre and post-test. The percentages of the questions in the pre-test were given in Table 1.

Table 1. *The percentages of pre- Renewable Energy Awareness Questionnaire*

| | Percentages (%) | | | | |
|---|-----------------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 |
| 1.They always involve energy sources whose availability is unlimited | 34.8 | 43.8 | 12.4 | 5.6 | 3.4 |
| 2.The renewable energy means energy that does not increase pollution and that does not deplete resources | 38.2 | 42.7 | 9.0 | 7.9 | 2.2 |
| 3.Solar energy is only applied in warm regions | 4.5 | 15.7 | 11.2 | 40.4 | 28.1 |
| 4.The technology of renewable energy does not work unless it reaches sources of energy | 20.2 | 42.7 | 24.7 | 10.1 | 2.2 |
| 5.Turkey is a rich country about renewable energy sources | 32.6 | 38.2 | 21.3 | 6.7 | 1.1 |
| 6.The renewable energy is always cheaper than non-sustainable energy sources | 20.2 | 28.1 | 23.6 | 21.3 | 6.7 |
| 7.Solar energy is too expensive and is not technologically ready to mass use | 16.9 | 25.8 | 23.6 | 22.5 | 11.2 |
| 8.When the renewable energy is used, it never produces environmental pollution | 19.1 | 22.5 | 29.2 | 24.7 | 4.5 |
| 9.Turkey uses renewable energy sources to meet its necessity for energy | 3.4 | 14.6 | 19.1 | 38.2 | 24.7 |
| 10.Renewable energy sources will replace non- renewable energy sources in the future | 38.2 | 36.0 | 18.0 | 6.7 | 1.1 |
| 11.Solar energy panels are not actually environmentally friendly because energy consumed during manufacturing is larger than energy generated | 3.4 | 4.5 | 23.6 | 44.9 | 23.6 |
| 12.Turkey uses technologies of renewable energy effectively | 2.2 | 10.1 | 23.6 | 44.9 | 19.1 |
| 13.After installing solar energy panels, you will still need fossil fuel as a back-up energy source in cloudy and rainy days. | 1.1 | 25.8 | 31.5 | 33.7 | 7.9 |
| 14.Turkey is at the top of Europe rankings with respect to solar energy sources | 20.2 | 43.8 | 22.5 | 12.4 | 1.1 |
| 15.Turkey should give great importance on renewable energy technologies and use | 69.7 | 22.5 | 3.4 | 3.4 | 1.1 |
| 16.When only solar energy is used at home, our life quality can decrease due to necessity of huge power for modern instruments | 13.5 | 28.1 | 19.1 | 25.8 | 13.5 |
| 17.I believe that I have enough information on renewable energy | 3.4 | 13.5 | 37.1 | 41.6 | 4.5 |
| 18.I think that there are no adequate courses about renewable energy | 3.4 | 15.7 | 21.3 | 30.3 | 29.2 |
| 19.I think that there should be more courses about renewable energy in our curriculum | 57.3 | 27.0 | 10.1 | 3.4 | 2.2 |
| 20.I want to work on renewable energy field in the future | 67.4 | 25.8 | 3.4 | 1.1 | 2.2 |

Table 2. *The percentages of post- Renewable Energy Awareness Questionnaire*

| | Percentages (%) | | | | |
|---|-----------------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 |
| 1. They always involve energy sources whose availability is unlimited | 1.1 | 3.4 | 2.2 | 57.3 | 36.0 |
| 2. The renewable energy means energy that does not increase pollution and that does not deplete resources | 51.7 | 43.8 | 0 | 4.5 | 0 |
| 3. Solar energy is only applied in warm regions | 1.1 | 0 | 3.4 | 58.4 | 37.1 |
| 4. The technology of renewable energy does not work unless it reaches sources of energy | 4.5 | 9.0 | 10.1 | 57.3 | 18.0 |
| 5. Turkey is a rich country about renewable energy sources | 40.4 | 37.1 | 2.2 | 13.5 | 6.7 |
| 6. The renewable energy is always cheaper than non- | 4.5 | 3.4 | 3.4 | 51.7 | 37.1 |

| sustainable energy sources | | | | | |
|--|------|------|------|------|------|
| 7. Solar energy is too expensive and is not technologically ready to mass use | 4.5 | 4.5 | 9.0 | 60.7 | 21.3 |
| 8. When the renewable energy is used, it never produces environmental pollution | 4.5 | 12.4 | 6.7 | 53.9 | 22.5 |
| 9. Turkey uses renewable energy sources to meet its necessity for energy | 3.4 | 2.2 | 5.6 | 51.7 | 37.1 |
| 10. Renewable energy sources will replace non-renewable energy sources in the future | 16.9 | 31.5 | 15.7 | 28.1 | 7.9 |
| 11. Solar energy panels are not actually environmentally friendly because energy consumed during manufacturing is larger than energy generated | 1.1 | 6.7 | 15.7 | 52.8 | 23.6 |
| 12. Turkey uses technologies of renewable energy effectively | 0 | 6.7 | 14.6 | 43.8 | 34.8 |
| 13. After installing solar energy panels, you will still need fossil fuel as a back-up energy source in cloudy and rainy days. | 5.6 | 42.7 | 11.2 | 31.5 | 9.0 |
| 14. Turkey is at the top of Europe rankings with respect to solar energy sources | 30.3 | 46.1 | 5.6 | 14.6 | 3.4 |
| 15. Turkey should give great importance on renewable energy technologies and use | 75.3 | 21.3 | 1.1 | 1.1 | 1.1 |
| 16. When only solar energy is used at home, our life quality can decrease due to necessity of huge power for modern instruments | 13.5 | 21.3 | 19.1 | 34.8 | 11.2 |
| 17. I believe that I have enough information on renewable energy | 12.4 | 44.9 | 22.5 | 19.1 | 1.1 |
| 18. I think that there are no adequate courses about renewable energy | 6.7 | 15.7 | 16.9 | 37.1 | 23.6 |
| 19. I think that there should be more courses about renewable energy in our curriculum | 64.0 | 30.3 | 2.2 | 3.4 | 0 |
| 20. I want to work on renewable energy field in the future | 73.0 | 23.6 | 1.1 | 2.2 | 0 |

Renewable Energy

Renewable energy was investigated in items 1,2,4,6,8, and 10. In these statements, the general knowledge and misconceptions about renewable energy were stated and expected students to know these information.

In the first statement, the students' perceptions were investigated whether they know the renewable energy sources are limited or not. Before the courses, 78.7% percent of students believed that the sources are unlimited. However, 93.4% percent selected that they don't agree with this statement after the course.

The second statement explained what the definition of renewable energy is. There is no big difference between before and after the course based on students' perceptions. Before the course 80.9 % percent and after the course 95.5% percent chose that they agree with this sentence. That is, they generally know the definition.

In the fourth statement, one of the biggest misconceptions about renewable energy is whether renewable energy sources are always working or not. Actually, 62.9 % percent of the students believe that it does not work if there is no source of energy before the course. Yet, 24.7% percent of students selected that they are undecided and 13.3% percent selected that they are not agree with this statement. After the course, 75.3% percent think that they agree with this sentence. In fact, it is not a constant source and it works when it reaches sources. May be, technologically some solar cells or wind-tribunes can stock the source and use it when necessary.

Six statement presents that renewable energy sources are always cheaper than other fossil fuels. Before the course, 48.3% percent of the students strongly agree and agree with

this statement while this percent is 7.9% after the course. Indeed, the sources of renewable energy could pay for themselves. But, there are many factors for cost of energy such as its technology, amount of energy necessity. For example, the construction of solar panels is not cheap and it takes decades that compensate for its initial cost.

Regard to eight statement, it was stated that renewable energy never produces environmental pollution. Before the course, 41.6% percent of the student selected “agree” and “strongly agree” with this statement. But, after the course this proportion decreased 16.9. The students consider that environmental pollution is never generated by renewable energy. Actually, during the construction of renewable energy technologies, it can be some environmental pollution.

The last statement about renewable energy was whether the renewable energy would replace non-renewable energy exactly or not. Whereas 74.2% percent of the students believe that it would replace completely before the course, 48.3% percent think like that after the course. Actually, the students believe that renewable energy is good thing, thus it should replace in full. However, the fact is that the technology could not meet its demand.

Solar Energy

Solar energy, which is the most common and used renewable energy source in Turkey, was explored in items 3, 7, 11,13, and 16. As renewable energy items, these items included some misconceptions and knowledge about solar energy.

With regard to solar energy, the third statement told that solar energy could be used in warm regions. While 20.2 % percent thinks that they agree with this statement before the course, only 1.1% percent selected that they agree with this statement after the course. Before the course, they consider that the temperature of area affects the performance of solar cells. However, in the course, it was explained that solar cells could be used effectively under lower temperature and the enough sunlight for solar cells can be observed in cold regions.

In the seventh statement, it was asked whether solar energy is suitable for mass consumption or not. Before the course, 42.7 % percent of the students believe that solar energy is not suitable for mass use because of cost and deficiency of technologies. 82% percent of the students did not agree with this statement. They think that it can be used for mass use. It is fact that after decades of solar energy research and technological progress, pricing decreased and it caused reliable mass use.

The eleventh statement stated that the use of solar panels is environmentally unfriendly because of consuming energy during manufacturing. There are no big differences, which disagree with this statement, between before (68.5%) and after (76.4%) the course. National Renewable Energy reported that panels are paid back within 1 to 4 years based on type of the cell. The solar energy panels continue to function nearly 30 years thus it results in 26 to 29 years of zero- emission electricity.

The necessity of fossil fuels as a back-up energy source in cloudy and rainy days was presented in the thirteen statement. The percentages of students who disagree with this statement are nearly same in before (41.6%) and after (40.5%) the course. The students may think that fossil fuels are obligation in cloudy and rainy days. However, there is no necessity for back-up generator as long as your home is connected to grid.

The last statement about solar energy was that the life quality could be decreased because of necessity of huge power at home when using solar energy. While 39.3% percent of the students disagree with this statement before the course, 46.0 % percent disagree after the course. Actually, again there is no big difference between before and after the course. As mentioned above, homes still stay on grid after installing solar panels, power supply can support energy demand thus the life quality could not be decreased.

Perceptions about their departments and themselves

The perceptions about their departments and themselves were investigated in items 17, 18, 19, and 20.

Before the course, 16.9% percent of the students believe that they have enough information about renewable energy whereas 57.3% percent of the students believe like that after the course. In addition, approximately 60% percent of the students think that there is not enough courses in their departments and 94.4% percent of the students think that there should be more courses about renewable energy in their curriculum. Furthermore; nearly 95.0% percent of the students want to work on renewable energy field in their careers.

Interviews

The success of the course was not evaluated by questionnaire scores but also by interviews. Semi-structured interviews were conducted with 10 students. Some of their comments were presented below:

- I enjoy the course. It gives opportunity for us to learn deep information about renewable energy.
- The course is useful for us. I learn many things and in the discussion seminar I aware different perspective of my friends
- I really like the course. It provides us think in new about renewable energy that is already our subject.
- It is really great course. I learn much new information about renewable energy that is the main subject of my academic career.

Generally, they think that the course increase their awareness about renewable energy. They believe that they should be qualified person about renewable energy because their academic career is already interested in energy systems.

DISCUSSION

Necessity of energy, one of the most important challenges for the entire world, increases from day to day with population and industrialization. It is fact that in order to meet and handle these challenges, qualified people and consciousness of renewable energy are required. This requirement can be achieved by education. With an education, we tried to train and increase students' awareness to meet our future challenges. For this reason, we developed the course and investigated students' perceptions before and after the course by Renewable Energy Awareness Questionnaire.

Before the course, many students had some misconceptions about renewable energy. These misconceptions may cause from students' daily lives. They read and listen a lot of things about sustainability and renewable energy from newspaper, magazines, and TV. The most common misconception is that the availability of renewable energy sources is unlimited. It may cause of the meaning of renewable that refers "inexhaustible" in Turkish language. Another common misconception is about the cost of renewable energy. Majority of the students believe that renewable energy always is cheaper than other energy sources. They think that renewable energy sources are observed from nature thus money is not paid for them. Besides, several students think that renewable energy will replace with non-renewable energy in full. They think that renewable energy is good for nature and it can meet necessity of energy. Thus, they think that only renewable energy should be used in future.

With regard to solar energy, there are two common misconceptions that about its cost and its deficiency for mass use. Students believe that solar energy is too expensive and not

suitable for mass consumption due to technology deficiency. They consider that there is a huge demand for energy at home and solar energy cannot meet this necessity.

As for perceptions about their departments and themselves, they generally think that they are not qualified about renewable energy and there should be more courses about it. Although they are students in Energy System Engineering Department, they even think that they do not have enough information about renewable energy. On the contrary, the large majority, that is nearly all, considers that they want and hope career in renewable energy field. As reported in Emanuel, R and Adams, J.N (2011), students honestly give answers about their self-assessment of their knowledge about renewable energy.

With the course, the students are trained about the renewable energy. The course provides them to think in new and handle their misconceptions. Also, it gives an opportunity to increase their awareness in their own subjects. Thus, after the course, it is observed that there is a decrease in the percent of misconceptions.

As regard to evaluation of students on course, students believe that the course was the great and useful for them. They declared that explanations were deep and clear. The course showed them the different aspects of renewable energy and they learned them.

In this study, it was found that students in Energy System Engineering Department have many misconceptions about renewable energy as reported by Leal Filho (2000). Leal Filho reported that there were many sources of these misconceptions such as knowledge, background, experience, perception, values and context. We think that the main source of these misconceptions arise from daily experiences same as Leal Filho.

To sum up, this study found that although the students were in Energy System Engineering Department, they still had many misconceptions about renewable energy. After the course prepared by researcher many students handled their misconceptions and developed their knowledge about renewable energy.

CONCLUSION

To achieve sustainable future will need the development of awareness and knowledge of engineering students especially energy system engineering students about renewable energy. Mainly, in developing countries such as Turkey, developing renewable energy requires qualified people and consciousness of renewable energy.

Unfortunately, even Energy System Engineering students have many misconceptions about renewable energy. Although, there are many sources of these misconceptions, it should be overcome these misconceptions with education for welfare future.

Thus, in this study, we tried to train energy system engineering students about renewable energy. With this article, we would like to increase perceptions of engineering students on renewable energy and help them overcome their misconceptions about it. Affirmative evaluation of students on the whole learning outcomes show that the course meets the requirements of qualified people about renewable energy.

This study has demonstrated that as the course took place, the perceptions, and misconceptions of students about renewable energy changed. It also recommended that if the single course can achieve the changes of perceptions and misconceptions of students, consistent changes might be succeeded by curriculum. We hope that we could affect teachers and educators with our course to change and develop curriculum about renewable energy for sustainable future.

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Scientific Literacy Themes Coverage in the Nigerian Senior School Chemistry Curriculum

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Received: 12.04.2016

Revised: 16.06.2016

Accepted: 15.02.2017

The original language of article is English (v.14, n.2, June 2017, pp.52-64, doi: 10.12973/tused.10198a)

ABSTRACT

The current reforms in science education around the world emphasize science for all, with the ultimate goal of achieving scientific literacy. These reform initiatives provide platforms for re-designing coherent science curricula that could serve as resources for scientific literacy, and consequently, contribute to the development of scientifically literate citizens—who will be able to use scientific knowledge in their daily decision-making processes and other socio-scientific issues. This study, therefore, investigated the coverage of scientific literacy themes in the Nigerian senior school chemistry curriculum and examination questions. A framework developed by Chiappetta, Fillman and Sethna (1991) was adopted to analyze aspects of the curriculum and examination questions. The results revealed that the chemistry curriculum placed more emphasis on the knowledge of science and investigative nature of science. The examination questions mostly stressed investigative nature of science and science as a way of thinking. The interaction of science, technology and society was sparingly represented in the curriculum and the theory component of the examination questions, and almost absent in the practical questions. While the chemistry materials may have a prospect to contribute to the preparation of scientifically literate citizens, a re-adjustment to the structure of the chemistry curriculum and examination questions could provide a balance of the scientific literacy themes in chemistry materials.

Keywords: Science education reforms, scientific literacy themes, chemistry curriculum, examination questions

INTRODUCTION

The recent science education reforms as reflected in the national curricula and policies of different nations, place greater emphasis on the need to graduate students who will be able to function effectively in a scientific and technological society. For instance, the science education reforms in the United States of America, stress a science education that will promote scientific literacy among K-12 students (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). In the United Kingdom,



Holman (1997) reported that, the national curriculum accentuates the promotion of scientific literacy among students.

Similarly, the Nigerian national policy on science education emphasizes the teaching and learning of science processes and principles; which are anticipated to lead to fundamental and applied research in the sciences at all levels of education (Federal Republic of Nigeria, 2013). One common features of these national science education reforms among different countries, is the emphasis on the need for students to understand the interactions among science, technology, and society and be able to use this knowledge in their day-to-day decision-making processes (Mumba & Hunter, 2009).

There is no doubt that scientific literacy (SL) has been referred to as one of the major goals of science education as substantially reflected in several science education reforms and changing education policies taking place in the nations of the world. Scientific literacy is a broad term to define, and also appears controversial (Colagrande, Martorano & Arroio, 2016; Shwartz, Ben-Zvi & Hofstein, 2005). Reform documents describe scientific literacy as the ability to understand media accounts of science, to recognize and appreciate contributions of science, and to be able to use science in decision-making in daily life and socio-scientific issues (AAAS, 1993; NRC, 1996). In Nigeria, the education policy statement conceptualizes the goal of scientific literacy as the knowledge and understanding of the complexity of the physical world, vis-à-vis scientific concepts and processes required for good life and national development (Federal Republic of Nigeria, 2013). While several definitions exist for SL in the literature, science educators have come to agree that scientific literacy advocates for the development of a firm understanding of a range of scientific concepts, processes, awareness of the relationship among science, technology and society, and practices within and across science disciplines (Bauer, 1992; AAAS, 1993; Holman, 2002; Shwartz Ben-Zvi & Hofstein, 2006; Mumba & Hunter, 2009).

In line with these science education reforms and policy statements on education, science curriculum materials should ordinarily be designed or revised to meet the challenges of scientific literacy by providing curriculum materials that have adequate coverage of the scientific literacy themes, which include: (a) the knowledge of science (Theme 1); (b) the investigative nature of science (Theme 2); (c) science as a way of thinking (Theme 3); and (d) the interaction of science, technology and society (Theme 4) (Chiappetta, Sethna, & Fillman, 1993).

In the context of this research, there are previous studies that have analyzed science textbooks, curricula and examination questions for scientific literacy coverage, and reported imbalance in the representation of the scientific literacy themes, with emphases on the knowledge of science, and less attention on the other themes (BouJaoude, 2002; Chiappetta, Sethna, & Fillman, 1991; Lelliot, 2014; Lumpe & Beck, 1996; Mumba & Hunter, 2009; Ramnarain & Padayachee, 2015). Even though, Lelliot (2014) adopted Roberts' (2007, 2011) notions of vision I and vision II scientific literacy to analyze curricula statements and their approach to the concept of scientific literacy, the curricula documents were reported to have the dominance of the products and processes of science. In the analysis of South African life sciences and biology textbooks, Ramnarain and Padayachee (2015) recently reported that the textbooks did not reflect the aspirations of the current science education reforms that advocated for a more balanced coverage of the nature of science as a critical component of scientific literacy.

It is evident in the literature that studies in other countries on this important goal of science education, have only been channeled to examine science textbooks, with comparatively few studies on chemistry curriculum and examination questions (Cansiz & Turker, 2011; Erdogan & Koseoglu, 2012). Chemistry plays a very critical role in understanding the physical environment that is filled with chemical products (Gilbert &

Treagust, 2009). It is this understanding that helps people participate meaningfully in public debates and to make decisions about their everyday lives and environment (Irez & Çakir, 2006; Celik, 2014). Despite the critical role chemistry plays in promoting scientific literacy, there was no other research available to the researchers on scientific literacy themes coverage in any of the Nigerian senior school science curricula to the best of our knowledge, as at the time of this study.

The benefits of this research will not be limited to Nigeria only, but could be of international relevance to other developing countries that have revised their science curricula documents to align with the reforms advocacy, so as to confirm the possibilities of such documents to provide the needed scientifically literate citizens. For a country like Nigeria, that seeks to promote the study of science among its teeming population of young people; produce adequate number of scientists; and scientifically literate citizens capable enough to inspire and support national development, scientific literacy ought to be adequately reflected in our science curricula as a deliberate pursuit of the realization of these aspirations.

It is against these backdrops that we sought to investigate scientific literacy themes coverage in the Nigerian senior school chemistry curriculum and its potential to contribute to the preparation of scientifically literate citizens. Since chemistry curriculum encompasses examination questions, the chemistry questions of Senior School Certificate Examination conducted by the West African Examinations Council were included in our analysis. Within this scope, the study was guided by a research question on: What is the extent of coverage of the scientific literacy themes in the Nigerian senior school chemistry curriculum?

Scientific Literacy and the Nigerian Senior School Chemistry Curriculum

In Nigeria, the science curricula projects (African Primary Science Programme, Nigerian Integrated Science Project, *etc.*) which have been phased out, were well-intentioned and initially developed to promote scientific literacy among learners. However, these science curricula were not adequately implemented. Teachers taught science from textbooks adopted from developed countries and students ended up learning science contents, without sufficient understanding of its relevance to their day-to-day living and decision-making processes (Abimbola, 2009). In the wake of the 21st century, when the advocacy for science education reform initiatives became stronger, science curricula were revised to better position the curricula to inform and produce scientifically literate citizens.

The current chemistry curriculum was adapted and revised from the 1985 editions developed by Comparative Education Study and Adaptation Centre (CESAC). The curriculum was written and published in 2007 by university lecturers and senior school chemistry teachers in conjunction with the Nigerian Educational Research and Development Council (NERDC), and adopted by the Federal Ministry of Education for use in schools in 2009. In the curriculum document, the objectives of this curriculum were said to have been derived from the national policy statements on education, which are: “to prepare students with the basic knowledge in chemical concepts and principles through efficient selection of contents and sequencing; to acquire the ability to apply scientific knowledge to everyday life in matters of personal and societal needs, among others” (NERDC, 2009, p. 4).

In selecting the contents, three major issues – globalization; information and communication technology and entrepreneurship, that shape the development of nations worldwide, dictated the organization of the contents around four themes of: (i) the chemical world; (ii) chemistry and environment; (iii) chemistry and industry; and (iv) chemistry and life. Table 1 presents the summary of the Nigerian senior school chemistry curriculum, which includes the topics to be taught and the thematic approaches used in the revised curriculum (Oloruntegbe & Agbayewa, 2013).

Table 1. Summary of the Nigerian Senior School (SS) 1-3 Chemistry Curriculum

| Theme/Year | SS1 | SS2 | SS3 |
|----------------------------------|--|--|---|
| Chemistry and Industry | Chemistry and Industries | Periodic table, Chemical reactions, Mass-volume Relationship | Quantitative and qualitative analysis |
| The Chemical World | Introduction to chemistry, Particulate nature of matter, Symbols, formulae and equations, Chemical combination, Gas laws | Acid-base reactions, Water, Air, Hydrogen, Oxygen, Halogens, Nitrogen, Sulphur | Petroleum, Metal and their compound iron Ethical, legal and social issues |
| Chemistry and Environment | Standard separation techniques for mixtures, Acid, bases and salt, Water | Oxidation-reduction (redox) Reaction, Ionic theory, Electrolysis | Fats and oil, Soap and detergent, Giants molecules |
| The Chemistry of Life | Carbon and its Compounds | Hydrocarbons, Alkanols | |

Source. Adapted from Oloruntegbe and Agbayewa (2013).

Note. SS 1 – 3 represents senior school level of education in Nigeria, which is equivalent to Grade 10 – 12 in countries that use grade system.

In planning the new chemistry curriculum, a spiral approach to sequencing a science course was adopted. The spiral approach allows concepts/topics to be taught in greater depths as the course progresses, in such a way that a particular concept can run throughout the three years of senior school education (see Table 1).

The West African Senior School Certificate Examination (WASSCE) conducted by the West African Examinations Council (WAEC), is one of the foremost summative assessments to mark the end of senior secondary education in Nigeria. The WASSCE is a qualitative and reliable examination in West Africa that has a strong influence on learning, teaching, and assessment (Ojerinde, 2011).

Chemistry is one of the elective and non-vocational subjects students are examined in. The results from these examinations could influence students' progression to the next stage of education. The structure of the examination questions is designed by the Examination Boards of the member countries (Nigeria, Liberia, Ghana, Sierra Leone and Gambia), though, not limited to the objectives and contents of the national curriculum and syllabi operational in each of those countries.

For chemistry, there are three papers – Paper 1, Paper 2 and Paper 3. Candidates are usually required to take either Papers 1 and 2 or Papers 2 and 3 only. Paper 1 is a two-hour practical test, while paper 3 also test practical knowledge, but is an alternative to paper 1. The candidates are required to answer all the three questions. Two of the questions are on quantitative and qualitative analyses, while the third question test candidates' familiarity with the practical activities suggested in their teaching syllabuses (West African Examinations Council [WAEC], 2005).

Paper 2 is a three-hour theory paper that covers the entire syllabus and carries a total of 150 marks, i.e., 75% of the total marks of the external examination. The paper has two parts; Part A and Part B. Part A contains fifty multiple choice questions drawn from Section A of the syllabus, where candidates are required to answer all the questions within 60 minutes for 50 marks. In this study, only the essay (theory) and practical questions were analyzed for the coverage of the scientific literacy themes.

CONCEPTUAL FRAMEWORK FOR THE STUDY

This study is hinged on a framework/procedure developed by Chiappetta *et al.* (1991, 1993) to analyze chemistry curriculum. The framework was developed from reviews of literature on scientific literacy and has been extensively used by researchers to analyze science textbooks and curricula documents (Abd-El-Khalick, 2002; BouJaoude, 2002; Chiappetta & Fillman, 2007, Ramnarain & Padayachee, 2015). This framework is considered to have addressed the dimensions of scientific literacy within four themes of:

1. *The knowledge of science:* In this category, the intent of the texts should be to present, discuss, or ask the student to recall information, facts, concepts, principles, laws, theories, hypotheses, and models. The texts in this category require students to recall facts or information. This theme reflects the transmission of scientific knowledge where the student receives information.
2. *The investigative nature of science:* In this category, the intent of the text should stimulate thinking and doing by asking the student to ‘find out’. It reflects the active aspect of inquiry and learning, which involves the student in the methods and processes of science, such as observing, measuring, classifying, inferring, recording data, making calculations, experimenting. In this category, the texts would require students to answer a question through the use of charts, tables, and graphs; require students to make a calculation; require students to reason out an answer; or engage students in a thought experiment or activity.
3. *Science as a way of thinking:* In this category, the intent of the texts should illustrate how certain scientists, went about discoveries. This aspect of the nature of science represents thinking, reasoning and reflection, where the student is told about how the scientific enterprise operates. Texts in this category: describe how scientists experiment; show the historical development of an idea; emphasize the empirical nature and objectivity of science; illustrate the use of assumptions; show how science proceeds by inductive and deductive reasoning; give cause and effect relationships; and discuss evidence and proof.
4. *Interaction of Science, Technology, and Society:* In this category, the intent of the texts should illustrate the effects or impacts of science on society. This theme of scientific literacy relates to the application of science and how technology helps or hinders humankind. Texts in this category describe the usefulness of science and technology to society; recognize the negative effects of science and technology on society; discuss social issues related to science or technology; and bring out careers and jobs in scientific and technological fields.

BouJaoude (2002) made three adaptations to the framework that led to the expansion of Theme 4, to include “personal use of science to make everyday decisions, solve everyday problem and improve one’s life and the impact of ethical and moral concerns on these activities’ (p. 145). BouJaoude (2002) further argued that, the current discussions on the conceptions of the philosophy of science makes ‘science as a way of knowing’ to be more inclusive, rather than, science, being conceived, ‘as a way of thinking’. An expanded detail of each of the themes of scientific literacy that aligns with subsequent discussions of the conceptions of scientific literacy is presented in the texts above. This framework developed by Chiappetta *et al.* (1991) and the modified version advanced by BouJaoude (2002) was employed to analyze the scientific literacy themes coverage in the Nigerian senior school chemistry curriculum.

RESEARCH METHODS

A mixed-method research design that employed content analysis was used to analyze the senior school chemistry curriculum and examinations questions. A valid and reliable procedure developed by Chiappetta *et al.* (1991, 1993) was used to analyze the documents. A typical example on electrolysis shows of the three components of the curriculum and the units analyzed or examined for scientific literacy coverage in Table 2.

Table 2. *An Example of the three Components of the Curriculum and the Units Analyzed*

| Topic | Performance Objectives | Students' Activities | Evaluation Guide |
|--------------|---|--|---|
| Electrolysis | Students should be able to: (i) explain the quantitative aspects of electrolysis | Set-up an electrolytic cell | Define electrolysis |
| | (ii) illustrate the electrolysis of acidified water, Copper(II) sulphate and brine | Explain the electrolysis of acidified water, Copper(II) sulphate and brine | Set-up the electrolytic and electrochemical cells |
| | (iii) construct the electrolytic and electrochemical cells | Describe the principle of Hoffman's voltammeter in the electrolysis of acidified water | Carryout the electrolysis of acidified water |
| | Explain the uses of electrolysis in extraction of metal and purification | State the uses of electrolysis | State the uses of electrolysis |

Source. Adapted from the Nigerian Senior School (SS) 1-3 Chemistry Curriculum (NERDC, 2009)

The data sources for this study were 585 units of the performance objectives, students' activities and the evaluation guides of the chemistry curriculum and 398 questions drawn from the senior school certificate examinations conducted by the West African Senior School Certificate Examinations (WASSCE) for a period of 5 years from 2010 – 2014. In each year, there were four questions with many parts for students to answer. For ease of analysis, each of the many parts of a question was taken as a unit or single question to be analyzed. In coding the units for analysis, a deductive approach was used to analyze the texts according to the framework of Chiappetta *et al.* (1991). Examples of units that agree with the categories of each of the scientific literacy themes are presented alongside the quantitative data in the research findings section.

To ensure reliability of the study, a random selection of 10% of the curriculum units and chemistry (theory and practical) questions were analyzed. From the curriculum document and examination questions, specific texts were identified and selected for analysis by using a random-number generator (www.random.org). The selected texts were independently analyzed by one of the researchers and a Professor of science education who understands the goal of scientific literacy, its representations in curricula contents and examination questions.

The values of Kappa's measure of agreement were calculated based on the classification of the peer-raters, for each of the performance objectives, students' activities, evaluation guides, chemistry theory and practical questions. The Kappa-values for the performance objectives, students' activities, evaluation guides, chemistry theory and practical questions were .68, .74, .82, .86 and .67 respectively. The substantial Kappa-values ($\kappa > .65$) for the units analyzed indicated a good measure of agreement between the two raters, which consequently, guaranteed a good reliability for the study.

RESEARCH FINDINGS

The objectives of the chemistry curriculum make clear reference to all the four themes of scientific literacy framework provided by Chiappetta *et al.* (1991). The objectives of the curriculum are to:

facilitate a smooth transition in the use of scientific concepts and techniques acquired in the new Basic Science and Technology curriculum with chemistry [Themes 1 & 2]; provide students with basic knowledge in chemical concepts and principles through efficient selection of content; enable students to appreciate the scientific method which involves experimentation, accurate observation, recording, deduction and interpretation of scientific data; enable students to develop laboratory skills, including an awareness of hazards in the laboratory and the safety measures required to prevent them; create an awareness of the inter-relationship between chemistry and other disciplines [Themes 2 & 3]; show chemistry and its link with the industry, the environment and everyday life, in terms of benefits and hazards [Theme 4].

These excerpts from the objectives of the chemistry curriculum overtly justify the intentions the developers of the curriculum to provide contents capable of producing scientifically literate citizens' outline in the framework for analysis.

Table 3 indicates that all the four themes were represented in varying degrees in the performance objectives of the curriculum. However, there were inconsistencies in the representation of the themes in the objectives from SS1 to SS3. The basic knowledge of science received the most emphasis (45.1%), followed by science as a way of thinking (26.2%), then the investigative nature of science (22.4%) and the interaction of science, technology and society (6.3%).

Table 3. Representations of the Scientific Literacy Themes in the Performance Objectives of the Curriculum

| Performance objectives | Scientific literacy themes | | | | | | | | Total | |
|------------------------|--------------------------------|-------------|-------------------------------------|-------------|------------------------------|-------------|--|------------|------------|------------|
| | The basic knowledge of science | | The investigative nature of science | | Science as a way of thinking | | Interaction of science, technology and society | | | |
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % | Freq. | % |
| Senior School 1 | 24 | 38.1 | 19 | 30.2 | 14 | 22.2 | 6 | 9.5 | 63 | 26.6 |
| Senior School 2 | 49 | 45.5 | 22 | 20.4 | 35 | 32.4 | 2 | 1.9 | 108 | 45.6 |
| Senior School 3 | 34 | 51.5 | 12 | 18.2 | 13 | 19.7 | 7 | 10.6 | 66 | 27.8 |
| Total | 107 | 45.1 | 53 | 22.4 | 62 | 26.2 | 15 | 6.3 | 237 | 100 |

Table 4 contains scientific literacy themes coverage in students' activities in the curriculum for the three senior school years. On average, investigative nature of science (53.8%) is the most represented theme in students' activities, followed by the basic knowledge of science (27.8%), science as a way of thinking (14.8%) and the interaction of science, technology and society (3.6%).

The emphasis on Theme 2 reflects active inquiry and learning, where students are actively involved in the scientific processes. For example, the intent of the excerpts on students' activities below engages students in well-thought experiments:

Prepare standard solutions, carry out acid-base titrations using given indications and record titre values correctly to 2 decimal places. Carry out experiments on the removal of hardness of water by boiling and the addition of washing soda. Observe the experiment on the laboratory preparation of chlorine, and record your

observations. Demonstrate the bleaching action of chlorine [Theme 2] (Senior Secondary Education Curriculum, Chemistry for SS 1 – 3, Chemistry and Environment, Pp. 16, 17 & 21).

Table 4. Representations of the Scientific Literacy Themes in the Students' Activities of the Chemistry Curriculum

| Students' Activities | Scientific literacy themes | | | | | | | | | |
|----------------------|--------------------------------|-------------|-------------------------------------|-------------|------------------------------|-------------|--|------------|------------|------------|
| | The basic knowledge of science | | The investigative nature of science | | Science as a way of thinking | | Interaction of science, technology and society | | Total | |
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % | Freq. | % |
| Senior School 1 | 14 | 20.4 | 24 | 45.3 | 12 | 22.6 | 3 | 5.7 | 53 | 41.4 |
| Senior School 2 | 22 | 27.5 | 45 | 56.2 | 12 | 15.0 | 1 | 1.2 | 80 | 47/3 |
| Senior School 3 | 11 | 30.6 | 22 | 61.1 | 1 | 2.8 | 2 | 5.6 | 36 | 21.3 |
| Total | 47 | 27.8 | 91 | 53.8 | 25 | 14.8 | 6 | 3.6 | 169 | 100 |

Table 5 presents the frequency and percentage distribution of the scientific literacy themes coverage in the evaluation guides/questions of the curriculum. From the Table, basic knowledge of science is the most emphasized with 54.7%, while investigative nature of science and science as a way of thinking were marginally at 19.6% and 20.7% respectively. Lesser focus was on science as a way of thinking and investigative nature of science, which would have engaged students in cognitively demanding tasks or activities that requires reasoning out the answers. The interaction of science, technology and society is the least emphasized in the evaluation questions.

It is noted earlier that the design of the chemistry curriculum adopted a thematic approach where the different topics were grouped around the four themes of *chemistry and industry*, *the chemical world*, *chemistry and environment* and *the chemistry of life*. Examples of evaluation guides or questions drawn from *chemistry of life* expected to be covered at the third year of senior secondary school is given as:

Name substances that contain fats and oils. List the physical and chemical properties of fats and oils. Define saponification... State the uses of fats and oils [Theme 1] (Senior Secondary Education Curriculum, Chemistry for SS 1 – 3, Chemistry of Life, p. 36).

The intent of these questions is to ask students to recall knowledge about fats and oils, state or list the properties of fats and oils and their uses.

Table 5. Representations of the Scientific Literacy Themes in the Evaluation Questions of the Curriculum

| Evaluation questions | Scientific literacy themes | | | | | | | | | |
|----------------------|--------------------------------|-------------|-------------------------------------|-------------|------------------------------|-------------|--|------------|------------|------------|
| | The basic knowledge of science | | The investigative nature of science | | Science as a way of thinking | | Interaction of science, technology and society | | Total | |
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % | Freq. | % |
| Senior School 1 | 30 | 60.0 | 10 | 20.0 | 7 | 14.0 | 3 | 6.0 | 50 | 27.9 |
| Senior School 2 | 46 | 52.9 | 19 | 21.8 | 21 | 24.1 | 1 | 1.1 | 87 | 48.6 |
| Senior School 3 | 22 | 52.4 | 6 | 14.3 | 9 | 21.4 | 5 | 11.9 | 42 | 23.5 |
| Total | 98 | 54.7 | 35 | 19.6 | 37 | 20.7 | 9 | 5.0 | 179 | 100 |

Table 6 demonstrates that scientific literacy themes were also represented in the chemistry examination questions. The chemistry paper 2 (theory) placed more emphasis on investigative nature of science (38.1%), while knowledge of science and science as a way of thinking (25.0%) were the next emphasized, followed by interaction of science, technology and society (11.9%).

It is evident in Table 6 that; investigative nature of science was the most emphasized in each of the examination years from 2010 – 2014. Even though, the questions were not such that actively engage students in well-thought experiments or activities, the questions classified under Theme 2 reflects the processes of science and the active aspect of inquiry and learning. For example, the question below reflects the representation of some of the scientific literacy themes:

i. Define each of the following terms. I. biotechnology; II biogas ii. State two applications of biotechnology. b (i). Describe briefly the production of ethanol from sugarcane juice. (ii). State the by-products of the process in b (ii). b (iii). Mention two uses of the by-products. (iv). Ethanol can be produced from both sugarcane and petroleum. Explain briefly why the ethanol from sugarcane is renewable, but that from petroleum is non-renewable [Theme 1, 2 and 4] (WASSCE Chemistry Paper 2, 2012).

The intent of this question does not only require students to recall information about biotechnology and biogas, but also to explain scientific processes, in this case, the process(es) of producing ethanol from sugarcane. Part of the questions would also require students to state the applications of biotechnology (domestic and industrial applications), some of which could be consumables, while others are non-consumables, but useful to mankind.

Table 6. Frequency and Percentage Distributions of Scientific Literacy Themes in the SSCE Chemistry Questions

| Years | Scientific literacy themes | | | | | | | | | |
|--------------|--------------------------------|-------------|-------------------------------------|-------------|------------------------------|-------------|--|-------------|------------|------------|
| | The basic knowledge of science | | The investigative nature of science | | Science as a way of thinking | | Interaction of science, technology and society | | Total | |
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % | Freq. | % |
| 2010 | 17 | 27.4 | 27 | 43.5 | 11 | 17.7 | 7 | 11.3 | 62 | 18.9 |
| 2011 | 16 | 19.8 | 31 | 38.3 | 25 | 30.9 | 9 | 11.1 | 81 | 24.7 |
| 2012 | 17 | 26.6 | 24 | 37.5 | 15 | 23.4 | 8 | 12.5 | 64 | 19.5 |
| 2013 | 13 | 21.7 | 23 | 38.3 | 19 | 31.7 | 5 | 8.3 | 60 | 18.3 |
| 2014 | 19 | 31.1 | 20 | 32.8 | 12 | 19.7 | 10 | 16.4 | 61 | 18.6 |
| Total | 82 | 25.0 | 125 | 38.1 | 82 | 25.0 | 39 | 11.9 | 328 | 100 |

The results in Table 7 presents the scientific literacy themes coverage in the practical chemistry questions (paper 1) from 2010 – 2014. From the Table, it is expected that more questions are classified under Theme 2, with investigative nature of science (54.3%) as the most emphasized, followed by science as a way of thinking (28.6%), then basic knowledge of science (12.9%). The interaction of science, technology and society (4.3%) was the least emphasized in the chemistry practical questions.

In some of the examination years (2010, 2012 and 2014), interactions of science, technology and society did not appear in the practical questions. While basic knowledge of science did not feature in the 2010 practical questions, comparatively fewer questions require the knowledge of science to solve in the other years, except for year 2012 with more questions. The SL Theme 3 was represented in each of the years, but the questions were fewer compare to practical questions on Theme 2.

Table 7. Representations of the Scientific Literacy Themes in the SSCE Chemistry Practical Questions

| Years | Scientific literacy themes | | | | | | | | Total | |
|--------------|--------------------------------|-------------|-------------------------------------|-------------|------------------------------|-------------|--|------------|-----------|------------|
| | The basic knowledge of science | | The investigative nature of science | | Science as a way of thinking | | Interaction of science, technology and society | | | |
| | Freq. | % | Freq. | % | Freq. | % | Freq. | % | Freq. | % |
| 2010 | 0 | 0 | 10 | 67.7 | 5 | 33.3 | 0 | 0 | 15 | 21.4 |
| 2011 | 1 | 7.7 | 7 | 53.8 | 3 | 23.1 | 2 | 15.4 | 13 | 18.6 |
| 2012 | 5 | 31.2 | 7 | 43.8 | 4 | 25.0 | 0 | 0 | 16 | 22.9 |
| 2013 | 2 | 15.4 | 6 | 46.2 | 4 | 30.8 | 1 | 7.7 | 13 | 18.6 |
| 2014 | 1 | 7.7 | 8 | 61.5 | 4 | 30.8 | 0 | 0 | 13 | 18.6 |
| Total | 9 | 12.9 | 38 | 54.3 | 20 | 28.6 | 3 | 4.3 | 70 | 100 |

For example, the following question provides an evidence for theme 2:

C contains two cations and two anions. Perform the following exercises on *C*. Record your observation and identify any gas(es) evolved. State the conclusion you draw from the result of each test (Table 8). (a). Dissolve all of *C* in about 10 cm³ of distilled water. Stir the resulting solution thoroughly.

Table 8. Practical Chemistry Questions (see the attached text)

| No. | Test | Observation | Inference |
|------|---|-------------|-----------|
| i. | To about 2 cm ³ of the solution, add few drops of AgNO ₃ followed by HNO _{3(aq)} . To the mixture add excess NH _{3(aq)} . | | |
| ii. | To another 2 cm ³ portion of the solution, add dilute HCl, followed by BaCl ₂ solution. | | |
| iii. | To another 2 cm ³ portion of the solution, add NaOH _(aq) dropwise, and then in excess. Warm the mixture. | | |
| iv. | To another 2 cm ³ portion of the solution, add NH _{3(aq)} dropwise, and then in excess. | | |

[Theme 2] (WASSCE Chemistry Paper 1, Practical Question 2, 2014).

This question requires students to carry out an experiment, report observations, draw inferences, and to ultimately suggest a chemical formula for *C* at the last stage of the experiment in the column for inference, which students will have to reason out on the basis of the inferences.

DISCUSSION AND CONCLUSION

The aim of this study was to examine the scientific literacy themes coverage in the Nigerian senior school chemistry curriculum and chemistry examination questions for a period of 5 years. The results of this study revealed that the knowledge of science was the most covered theme, followed by investigative nature of science, then science as a way of thinking and the interaction of science, technology and the society. This finding is consistent with the reports of previous studies on science curricula (BouJaoude, 2002, Cansiz & Turker, 2011, Erdogan & Koseoglu, 2012; Mumba & Hunter, 2006; Ramnarain & Padayachee, 2015). The study of BouJaoude (2002), analyzed Lebanese science curriculum for scientific literacy themes (Chiappetta *et al.*, 1991), and reported the emphases on scientific literacy themes 1, 2 4, and the neglect of science as a way of thinking (Theme 3). In the same vein, Erdogan and Koseoglu, (2012) concluded that the representation of the scientific literacy

themes was not proportionate, and the understanding of the nature of science was inadequate. These findings confirm the observation that the chemistry curriculum focuses more on the accumulation of facts, concepts, generalizations, laws and theories than the other themes of the scientific literacy.

From this result, a realization that the curriculum is a vital component of science education and the significant role it plays in chemistry instruction raises a serious concern on why the *basic knowledge of science* (Theme 1) is emphasized more than necessary in the chemistry curriculum. This finding suggests that the curriculum developers did not develop the chemistry contents in line with the objectives the curriculum had intended to achieve. An implication of this finding is that teachers who implement this curriculum may as well limit their emphases in classroom instructions to mainly the delivery of chemistry concepts, facts and a little of scientific processes.

The chemistry examination questions analyzed revealed that the WASSCE chemistry paper 2 (theory) had a fairly adequate coverage of Themes 1, 2 and 3, except Theme 4 that was lesser, about 11.9%. It is adjudged fair in comparison with the coverage of the chemistry curriculum. This result could be attributed to the nature of the WAEC chemistry questions, which may not be necessarily limited to the national curriculum of any of the 5 member countries, but are questions drawn to reflect the objectives of the chemistry syllabi of the countries that clearly seek to promote scientific literacy. The chemistry paper 1 (practical questions), placed more emphasis on the investigative nature of science, then, science as a way of thinking. This finding is expected as laboratory-based examinations should be inquiry-based and should seek to assess students' understanding of the processes of science. These results are fairly similar to the findings of Mumba and Hunter (2009), where all the themes had an excellent representation of the four themes of scientific literacy in both chemistry theory and practical questions. These results indicated that the chemistry questions have the potential to promote active aspect of inquiry, and develop students' thinking processes, but may not be sufficient enough to prepare scientifically literate populace. The implication of a curriculum that does not adequately covers the scientific literacy themes is reflected in the examination questions. Therefore, it could really be difficult for teachers to understand, explicitly teach and assess students in chemistry from the perspective of current paradigms of science that underpin students to effectively function as scientifically literate citizens after school.

The findings of this study has shown that, the chemistry curriculum and examination questions did not provide adequate coverage of the scientific literacy themes. Though, the four themes were represented in the curriculum documents, but not in equal representations. For a country whose education policy statements conceptualize scientific literacy goals as the understanding of scientific concepts and processes required for good life and national development, an adequate coverage of the scientific literacy themes in terms of knowledge and depth of engagement that is explicit-reflective, should be reflected in chemistry curriculum for students' learning experience.

RECOMMENDATIONS

Based on the outcomes of this study, it is recommended that, curriculum developers should re-structure the chemistry curriculum to provide the scientific literacy themes in all the units of the curriculum in equal proportions. This could involve a deliberate effort to present chemistry curriculum objectives and contents that reflect the core concepts, theories and models put forward by science to explain the natural world; the methods employed by scientists to gain new knowledge and how scientific and technological enterprise relates to societal issues and problems. Once this is achieved, test developers are likely to adjust

subsequent examination questions to reflect the scientific literacy themes that aligns with the goals of the examinations.

ACKNOWLEDGMENTS

The authors would like to thank Prof. Dr. Salih ÇEPNİ, Prof. I. O. ABIMBOLA and the anonymous reviewers for their assistance, scholarly comments and suggestions that were invaluable to this manuscript.

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The Effect of a Developed REACT Strategy on the Conceptual Understanding of Students: "Particulate Nature of Matter"

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Received: 06.05.2016

Revised: 20.10.2016

Accepted: 01.12.2016

The original language of article is English (v.14, n.2, June 2017, pp. 65-81, doi: 10.12973/tused.10199a)

ABSTRACT

The purpose of this study is to investigate the effect of REACT strategy developed in relation to "Particulate nature of the matter" subject on academic achievement and conceptual change. This study was accompanied by pre-test – post-test control group design. The academic achievement and concept test, which were developed, was distributed to 55 experimental group students and 47 control group students, which makes 102 learners in total. These learners are studying at 6th grade. REACT strategy was implemented on experimental group. Control group was exposed to current Science and Technology Curriculum. As a result of conducted implementations, it was detected that both academic achievement and conceptual change of experimental group students are better than control group students. Therefore, it is possible to say that REACT strategy is more efficient than the Ministry of National Education's curriculum. Interview with students in the direction of determined objective in addition to academic achievement and concept test may be recommended for future studies.

Keywords: Conceptual Change, Context, Matter, Particle, REACT.

INTRODUCTION

According to constructivist approach, learning takes place when pre-knowledge of individuals interacts with new information and when they are compared which leads to emergence of new conceptual structures. Pre-knowledge of learners or alternative concepts are playing important roles both in designing instruction and in learning of learners. One of the most important factors influencing learner achievement negatively is alternative concepts. The change in these concepts is of importance for constructivist approach (Cobern, 1994; Duit & Treagust, 2003; Sinatra & Broughton, 2011). Science is the effort to understand the events of nature (Bybee, 1991; Çepni, 2014; Hurd, 1975). Students misinterpret the events of nature because of alternative concepts (Duit & Treagust, 2003). Thus, these alternative concepts, which reduce the efficiency of educational practices and situated in students' minds, should be analyzed through conceptual change process (Duit & Treagust, 2003; Johnson, 1998).

"Particulate nature of the matter" is one of the subjects on which learners have maximum number of alternative concepts (Adadan, Trundle & Irving 2010; Adbo & Taber,



2009; Ayas, Özmen & Çalık, 2009; Aydeniz & Kotowski, 2012; Boz, 2006; Bunce & Gabel, 2002; Gomez, Benarroch & Marin, 2006; Kokkotas, Vlachos & Koulaidis, 1998; Maskill, Cachapuz & Koulaidis, 1997; Nakhleh & Samarapungavan, 1999; Özmen, Ayas & Coştu, 2002; Taber & Garcia-Franco, 2010; Tsitsipis, Stamovlasis & Papageorgiou, 2010). This subject is included in science and technology curriculum for 6th grade that was revised in 2005 in Turkey. Based on this subject, students learnt that matters are constituted of particles and these particles are called “atoms”. It was followed by subjects covering “elements, compounds and molecules”. Therefore, atom concept and properties of this concept should be constructed accurately in the minds of the students so as to facilitate the learning of other concepts. However, conducted studies still indicate that students have alternative concepts regarding “atom” concept. For instance, students believe that atom is living beings (Griffiths & Preston, 1992; Harrison & Treagust, 1996; Kenan, 2005). They even assume that atoms in living beings are animate while the atoms in non-living beings are not animate (Özalp & Kahveci, 2011). They think that atoms of the objects are different even if they are made of the same matter (Pideci, 2002; Kenan, 2005). The other beliefs are as follows: a matter can be divided until there is nothing left (De Vos & Verdonk, 1996; Novick & Nausbaum, 1981; Stavy, 1990; Nakhleh, 1992), scientists have seen atoms and it is possible to see them through a microscope (Bektaş, 2003; Griffiths & Preston, 1992; Ireson, 2000; Nakhleh & Samarapungavan, 1999), air does not have a mass or volume since it cannot be seen (Valanides, 2000) atom looks like a solid globe with its compounds and it has simple circulations within a circle (Bektaş, 2003; Griffiths & Preston, 1992; Harrison & Treagust, 1996).

One of the reasons as to why students have difficulty in comprehending this subject (Boz, 2006; Brook, Briggs & Driver, 1984; Özmen, 2011a; Özmen, 2011b; Tsai, 1999) is that they are incapable of associating the science concepts with the ones they encounter (Burbules & Linn, 1991; Gilbert, 2006; Stolk, Bulte, De Jong & Pilot, 2009, 2012). Another reason is that they have low levels of interests and motivations towards the course (Wolters & Rosenthal, 2000). McLeod (2003) states that in learning environments where constructivist approach was adopted, the instruction should be based on a context to draw the attention of the student that distinguishes these environments from the other ones. In order to draw the attention of the student, it is important to make them perceive how they will benefit from what is being taught. This can only be achieved within a context (Morrison, Ross, Kemp & Kalman, 2010).

Context Based Learning

If the aim is to teach a concept, scientific aspect of that concept and its role in our lives should be combined. The concept should be considered as an implementation of the real world (King, Bellocchi & Ritchie, 2008; Whitelegg & Parry, 1999). According to context based learning theory, individuals make associations based on the examples of daily life. By gaining experience, they start to learn. (Choi & Johnson, 2005). What distinguishes context based learning from other theories that adopted constructivist approach is this philosophy. Main purpose of this theory, which was started to be employed in 1980, is to raise the attention of students towards science and to make them realize the association between real life issues and science (Bennett, Hogarth & Lubben, 2003). A teacher who prepares himself/herself according to context based learning theory cannot ignore prior knowledge of students on which the new ones will be constructed. In order to overcome the differences among students, s/he creates a common ground by building contexts during education (Whitelegg & Parry, 1999). Therefore, employing context is of importance for science education (Gilbert, 2008).

That students cannot find answer to the question, “Why do I have to learn this subject?” influence their interests and motivations as well as conceptual change processes (Gilbert, Bulte & Pilot, 2011; Gilbert, 2008). Finding an answer to this question will increase both their motivations and their academic achievements (Bennett & Lubben, 2006). According to context based learning, the answer to this question should be given within the instruction process.

Thus, students should learn particulate nature of the matter in such a way that a context will be provided to make them associate it with their own experiences and lives. If students know they will use what they learn to interpret the events of their daily life, this will have a positive effect on their conceptual change processes (Gilbert, 2008). Therefore, REACT strategy is one of the ways to practice a theory based on context. This strategy is claimed to create an environment to make association between scientific concepts and context. It is also believed that this strategy is effective on both conceptual change and academic achievement (Ayvaci, Er Nas & Dilber, 2016; Er Nas, Şenel Çoruhlu & Kirman Bilgin, 2016; Ingram, 2003; Kirman Bilgin & Yiğit, 2017a,b).

REACT strategy

An organization named The Center of Occupational Research and Development (CORD) created REACT strategy as a result of studies conducted due to problems encountered in Math and Science. It consists of “Relating– Experiencing– Applying – Cooperating– Transferring” stages. It assists teachers and students to make associations between concepts regarding the subject and the context derived from real life experiences. It raises the interest and motivation towards course. Teachers may start the instruction by asking a question regarding a situation that may be encountered in daily life. The context or properties are brought into classroom. Students experience laboratory activities such as finding, discovering and researching. After students experience the association between context and concept, professional aspect of the context is emphasized. Students communicate with their friends, share what they learn and discuss in a process. Transferring refers to a student’s implementation of what s/he learnt in a new context or a situation (Crawford & Witte, 1999; Hull, 1999; Crawford, 2001; Navarra, 2006).

Conducted studies on strategy shows that REACT strategy provides permanent learning (Demircioğlu, Vural & Demircioğlu, 2012; Ingram, 2003, Kirman Bilgin, Er Nas & Şenel Çoruhlu, 2017; Ültay, Durukan & Ültay, 2015).

Based on such proposals, this study aims at investigating the effect of REACT strategy developed in relation to “Particulate nature of the matter” subject this end, the questions below were tried to be answered:

- Is there a significant difference between pre-test and post-test scores of learners indicating an effect of instruction on academic achievement?
- Is there a significant difference between pre-test and post-test of learners indicating an effect of instruction on conceptual change?

METHODS

Quasi - experiment model and pre-test/post-test control group design is suitable for this research.

a) Sample

Sample of this study consists of 6th grade students from a primary school randomly selected in Trabzon province. There are four 6th grade classes in the school and two of them

were randomly assigned as experimental group while the others became control group. The study was conducted with 102 students in total 55 of which is in experimental group while the 47 were in control group.

b) Developing Data Collection Tools

Science and technology curriculum was investigated and researchers decided on the objectives of the first subject of “Particulate nature of the matter” unit, named as “Particles Making up the Matter”, in relation to Academic Achievement Test (AAT- App. 1). The subject covers eight gains. An instruction of six hours was prepared. AAT, prepared in accordance with gains and containing 16 multiple-choice questions. KR20 reliability coefficient value of measurements from the test was calculated as 0.89.

In order to measure conceptual comprehension of learners, concept test (CT - App. 2) containing 5 two-stage questions. First stages of first 5 questions are multiple choice questions while the other stage asks learners to write the reason of their selection. KR20 reliability coefficient value was calculated as 0.72.

c) Data Analysis

Pre-test results of AAT and CT were compared with non-parametric Mann-Whitney U test. As a result of the comparison, there was no significant difference between the scores of experimental and control groups both in terms of AAT and CT pre-test scores (Table 1). Since AAT post-test scores of experimental and control groups provide parametric testing propositions, they were compared with independent t-test while CT was compared with Mann-Whitney U test.

Table 1: Mann-Whitney U test results of AAT and CT pre-test scores

| Test | Group | N | Rank Ave. | Rank Tot. | U | P |
|------|--------------|----|-----------|-----------|----------|-----|
| AAT | Experimental | 55 | 53,19 | 2925,50 | 1,200 | .52 |
| | Control | 47 | 49,52 | 2327,50 | | |
| CT | Experimental | 55 | 47,88 | 2633,50 | 1093,500 | .17 |
| | Control | 47 | 55,73 | 2619,50 | | |

AAT consists of 11 questions in total. Each question scores 1 point. Learner responses of CT analysis were classified and scored separately. This scoring was performed with the classification in relation to two-stage test developed by Abraham, Grzybowski, Renner & Marek (1992). Table 2 shows how learner responses were classified, sample responses from question 4 and scored.

Table 2: CT response classification and scoring

| Classification | Score | Sample Responses |
|---|-------|--|
| Complete comprehension | 4 | There is no color of the particle regardless of the color and the state of matter. Also, air is a matter |
| Partial comprehension | 3 | The atoms of matter are colorless |
| Partial comprehension with alternative perception | 2 | The atoms are colorless, however there is no atom in air. |
| Alternative perception | 1 | We can not touch the air like a table. So there is no atom in air. |
| No comprehension | 0 | I do not know |

According to this classification, if a response contains all the components of the valid response, this means *complete comprehension*; if a response contains some of the components, this means *partial comprehension*; when the concept is understood yet if a

misunderstanding is detected, this means *partial comprehension with alternative perception*; and if a response contains illogical or incorrect information, this means *alternative perception*. *No comprehension* refers to responses irrelevant to the subject or ambiguous, rewriting of the selected response or no writing at all.

d) Instruction design

Contexts, considered as the starting point of discovering the importance of scientific knowledge, are especially important tools for science and technology courses (Bennett, Hogarth & Lubben, 2003; King, Winner & Ginns 2011). Context may appear in the form of theme, subject, problem, story, case, or as practice within the course (Wieringa, Janssen & Van Driel, 2011). Games, toys, market trips, meals or the events they experience in the streets may be used as context for children. However, these contexts should be enriched with texts, videos, discussions and in-class activities (CORD, 1998). Contexts to be used in teaching may include television news, newspaper's reports or other current events (URL 1). Context may sometimes be concrete in the form of television, radio or any other device as well as a natural phenomenon. In other words, any objects, events or concepts you encounter in your daily life may be a context (Bülbül & Aktaş, 2013). Besides, discussions or research activities may be carried out as teaching activities (URL 1). There are differences between REACT strategy and 5E teaching model. It is necessary to use context to attract the attention of the learner and to conduct group work according to REACT strategy. But, it is not necessary these specifications according to 5E teaching model (Ültay & Çalık, 2011)

Based on these properties, context selected for experimental group was bottled gas. Bottled gases, which we use in household or offices, are perfect examples to make students comprehend that gases have masses. This is because bottled gases used in Turkey are sold in 12 kg portions. Besides, when you shake these bottles, you hear the sound of a liquid since compressed petrol gas is used in them. This can be explained via compressibility of gases. Explosion of these bottles is a great example to explain expansion of gases. Thus, it is an appropriate context for gains of the subject.

The instruction designed for experimental group was prepared taking into account REACT strategy. The Table 3 below shows gains that were dealt with, the materials developed for these gains, alternative concept codes they contain and practice processes.

Table 3: Instruction design implemented on experimental group

| Phase of REACT | Gains | Alternative Concepts and Application time | Teaching Process |
|----------------|---|--|--|
| Relating | <i>"Compares compression and expansion properties of solid, liquid and gaseous matters" and "Infers that there are spaces in gaseous matters from the comparison of compression-expansion properties of them"</i> | Alternative concepts: 6,10,11,12 (Table 8) (40 minutes) | Ask what they think about the sound of liquid when they shake bottled gases and tubes. Discuss the association between the subject and the context. Conceptual change text is distributed for alternative concepts. |
| Experiencing | <i>"Realizes that matters can be divided into unseen particles via an experiment" and "Questions to what extent matters can be divided successively"</i> | Alternative concepts: 5,7 (Table 8) (40 minutes) | Let the student watch the first animation. In this animation, there are objects regarding the solid, liquid and gaseous states of the matter. By selecting any of these objects, the student tries to divide it constantly. S/he has particles every time at the end. Later, teacher emphasizes that each matter is made up of particles which are so small that they cannot be seen through the eyes. |

| | | | |
|--------------|---|--|---|
| Applying | <i>“States that all kinds of matters are made up of building stones which are difficult to be divided and they are too small to be seen” and “Building stones of the matter which are similar to globes are called atoms”</i> | Alternative concepts: 4,8,9,14 (Table 8) (40 minutes) | Let the student watch the second animation. In this animation, a student wonders what a leaf is made of. S/he examines the leaf under microscope and observes that it is made up of cells. Afterwards, students are asked what cells are made up of. Students discuss among themselves. Animation tries to explain that even a single cell consists of billions of atoms. Later, conceptual change text is distributed regarding relevant alternative concepts. |
| Cooperating | <i>“Realizes that opinions regarding the concept of atom change in time” and “Expresses that atoms are comprised of even smaller particles”</i> | Alternative concepts: 7, 15 (Table 8) (40 + 40 minutes) | Group work in relation to scientists such as “Democritus, John Dalton, Marie Curie and Becquerel” as well as their claims regarding the atom is performed. |
| Transferring | All of the gains | Alternative concepts: 1, 2, 3 (Table 8) (40 minutes) | A discussion environment is created asking “Are atoms in living beings animate while atoms in non-living things inanimate? Are atoms of objects with different shapes different even if they are made of same material?” questions and conceptual change text is distributed. Also, students are asked why bottled gases explode. The answers are discussed. |

Control group could be instructed using current instruction designed in conformity with 5E Teaching Model by Ministry of National Education (MNE, 2006, s.86-94). However, it was seen from the interview with the practice teacher that the teacher s/he carried out his/her own instruction instead of the curriculum. At the end of the observations, the instruction covering the same gains (Table 3) was implemented on control group and it is summarized with the following paragraph.

Table 4: Instruction design implemented on control group

Teaching Process and Application Time According to 5E Teaching Model

Firstly, the teacher asks questions about properties and states of the matter and gives examples. Then, s/he puts small stones into a syringe and compresses it. They discuss the results (40 minutes - Engagement). S/he adds sugar into the water and mixes it. They discuss the results (40 minutes - Exploration and Explanation). A reading text about the contributions of Democritus, John Dalton, Marie Curie and Becquerel is read (40 minutes - Elaboration). Evaluation questions in the book are answered (40 minutes - Evaluation). A test consisting multiple-choice questions is implemented on students (40+40 minutes - Evaluation).

FINDINGS

Table 5 shows results of independent t-test conducted in order to reveal if designed instruction created a significant difference on academic achievements of learners in terms of post-test scores.

Table 5: Independent t-test results of AAT post-test scores

| Group | N | Ave. | S | sd | T | p |
|--------------|----|-------|-------|-----|------|------|
| Experimental | 55 | 55,27 | 21,15 | 100 | 2,29 | ,024 |
| Control | 47 | 45,53 | 21,65 | | | |

When Table 5 comparing the AAT (Appendix 1) post-test scores of groups is examined, it is seen that there is a significant difference on behalf of experimental group, [t(100)=2.29, p<.05].

Table 6: Mann-Whitney U test results of CT post-test scores

| Group | N | Rank Ave. | Rank Tot. | U | p |
|--------------|----|-----------|-----------|--------|------|
| Experimental | 55 | 65,28 | 3590,50 | 534,50 | .000 |
| Control | 47 | 35,37 | 1662,50 | | |

CT Scores of experimental group, participated in the instruction designed to develop conceptual change, and control group were compared. As shown in Table 6, there is a significant difference between group scores on behalf of experimental group, [U:534,50, p<.001].

Responses of experimental group students for two-stage questions in CT are classified according to Table 2 and presented in App. 3. When the App. 3 is examined, it is remarkable that most of the learners with alternative concepts in experimental group resolved these concepts while some of them remained in the same conceptual level they had before. The change in alternative concepts of experimental and control group students is shown in Table 7.

Table 7: The Change in Alternative Concepts of Experimental and Control Group Students

| No | Alternative Concepts | Experimental Group | | Control Group | |
|----|--|--------------------|-------------|---------------|-------------|
| | | Pre-Test % | Post-Test % | Pre-Test % | Post-Test % |
| 1 | Atoms are animate due to their movements. | 27,2 | 1,8 | 14,8 | 8,5 |
| 2 | Atoms in living beings are animate while atoms in non-living things are inanimate. | 18,1 | 5,4 | 17 | 21,2 |
| 3 | Objects with different shapes have different atoms even if they are made of the same material. | 27,2 | 16,3 | 17 | 10,6 |
| 4 | There are atoms among the particles making up the matter. | 67,2 | 36,3 | 51 | 59,5 |
| 5 | A matter can be divided until there is nothing left. | 5,4 | 3,6 | 21,2 | 8,5 |
| 6 | If the matter is unseen, it means there is no matter. | 3,6 | 5,4 | 10,6 | 4,2 |
| 7 | Scientists saw the atoms. | 25,4 | 1,8 | 12,7 | 17 |
| 8 | Atoms are flat and there is another substance between them. | 3,6 | 3,6 | 10,6 | 2,1 |
| 9 | Atoms have a simple cycle within a circle. | 12,7 | 18,1 | 25,5 | 14,8 |
| 10 | Air is not a matter since it does not have a volume and mass. | 10,9 | 10,9 | 19,1 | 6,3 |
| 11 | Gases do not have mass. | 40 | 21,8 | 36,1 | 31,9 |
| 12 | Air is not a matter since it is unseen. | 18,1 | - | 23,4 | 10,6 |
| 13 | Atom looks like a solid globe with its components. | 27,2 | 18,1 | 21,2 | 23,4 |
| 14 | There is air between particles making up the matter. | 21,8 | 36,3 | 29,7 | 19,1 |
| 15 | Atoms are big enough to be seen by means of a microscope. | 16,3 | - | 14,8 | 6,3 |

Generally, it is seen that some of the alternative concepts decreased while some rose and others remained the same when Table 7 is examined. However, the difference in experimental group is more remarkable considering the decrease in the rates of alternative concepts. For example; the percentage of 7th alternative concept decreased from 25,4% to 1,8% in experimental group while it rose from 10,9% to 17% in control group. 15th alternative concept was totally eradicated in experimental group while it decreased from 14,8% to 6,3% in control group.

DISCUSSION and CONCLUSION

According to Table 7, alternative concepts “Atoms are animate due to their movements” (Tezcan & Salmaz, 2005) and “The atoms in living beings are animate while the atoms in non-living things are inanimate” is commonly adopted by learners (Griffiths & Preston, 1992; Pideci, 2002; Salmaz, 2002) Though there is a tremendous decrease in post-test, it is seen that some of the learners still keep them. This may stem from the fact that learners confuse the properties of cells and atoms. Learners may think that living beings are animate since atoms are animate and non-living things are not since atoms are inanimate which may be the root cause of this misconception. Özalp and Kahveci (2011) asked questions about the atoms of a leaf which is not torn apart from the plant. 46,7% of the class expressed that the atoms are animate. 50% of the response owners commented that “atoms are animate since the leaf is alive”. As seen from this example, learner opinions claiming that living beings can move attribute the characteristic of animation to atoms. 40% of control group students from Tezcan and Salmaz’s (2005) study think that atoms are animate thanks to the movements of the matters. However, these alternative concepts were rare limited to a few learners as seen from the post-test. This may stem from the fact that the discussion created and conceptual change text implemented in the class have been effective in changing these alternative concepts with scientific facts. The learners still had alternative concept of “Atoms of matters with different shapes are different even if they are made of the same material” (Griffiths & Preston, 1992) at a rate of 16,3%. This is because learners regard physical appearance as a distinguishing characteristic. Based on the fact that “the smallest building stone of the matter is atom”, learners may think that the reason why matters are different stem from atoms’ being different which may be another reason for the abovementioned misconception as well.

The alternative concepts of “There is space between the particles making up the matter” and “There are atoms between the particles making up the matter” (Griffiths & Preston, 1992; Pideci, 2002; Salmaz, 2002) are remarkable with a rate of 36,3% in post test accompanied by “Atoms are flat and there is another substance between them” (Griffiths & Preston, 1992) with a rate of 3,6%. This may be caused by the fact that learners could not concretize the concepts of atom-particle-matter and the quantities of their sizes, which did not allow learners to relate these concepts with each other and envisage the concept of *space* in their minds. While teaching the subjects in relation to Earth and Universe, the concept of space is used to define airspace. This might have made learners experience difficulty in imagining space between atoms. Thus, learners think that there are atoms or air between atoms.

In relation to movement and properties of atoms, the alternative concepts of “Atoms have a simple cycle within a circle” and “Atoms look like a solid globe with its components” (Bektaş, 2003; Griffiths & Preston, 1992; Ireson, 2000; Nakhleh & Samarapungavan, 1999; Tezcan & Salmaz, 2005) could not be replaced by scientific facts thoroughly. It is due to the fact that the symbols and scientific definitions as well as microscopic and macroscopic shapes in addition to daily life usages are not provided together and at the same time which led learners to have difficulty in envisaging them in mind. Çalık (2006) said that structuring of some of the alternative concepts requires a long process. This may apply to these alternative concepts, too.

The alternative concept of “Air is not a matter since it is unseen” (Bektaş, 2003; Nakhleh, 1992; Yeğnidemir, 2000) was not observed in the post-test. This indicates that *relating* step which conceptual change text was enough for this alternative concept to a great extent. The alternative concepts of “Air is not a matter since it does not have volume and mass”, “If the matter is unseen, it means there is no matter” (Bektaş, 2003; Nakhleh, 1992; Yeğnidemir, 2000) and “A matter can be divided until there is nothing left” (Bektaş, 2003;

Nakhleh, 1992; Stavy, 1990; Yeğnidemir, 2000) were observable in the post-test though at a quite low percentage. Learners have difficulty in concretizing and envisaging the matters they cannot see which may be the reason of this result (Çepni, Taş & Köse, 2006; Margel, Eylon & Scherz, 2004). As for the alternative concept of “Gases do not have mass” (Griffiths & Preston, 1992; Stavy, 1990), it decreased to a considerable extent in experimental group students yet still 18,1% had this idea in post-test. Learners consider air as an example to gaseous matter. Since they cannot see air, they cannot imagine it having a volume and mass. Thus, they believe that matter must be seen to prove its existence. It is clear that learners must accurately comprehend what kinds of properties change in matters while they are transiting between states.

When Table 7 is examined, it is seen that the alternative concept of “Scientists saw the atom” (Tezcan & Salmaz, 2005; Uzun 2010) has a rate of 1,8% while “Atoms are big enough to be seen by means of a microscope” (Bektaş, 2003; Griffiths & Preston, 1992; Harrison and Ireson, 2000; Lee & et al., 1993; Nakhleh & Samarapungavan, 1999; Treagust, 1996;) was not observed in the post-test. Control group has higher rate on this alternative concepts (see, Table 7) which indicates that REACT strategy implemented on experimental group is more effective than teaching implemented on control group. Tezcan and Salmaz (2005) conducted interviews regarding the same alternative concepts and accomplished a result at a rate of 40-20% from experimental group. Thus they stated that the developed material was not efficient enough for these alternative concepts. Current study led to a considerable decrease which indicates that the developed animation and conceptual change text were efficient for these alternative concepts.

When AAT and CT pre-test and post-test scores of experimental and control groups were analyzed, it is remarkably seen that experimental group progressed more positively than control group both in terms of academic achievement and conceptual change. The reason may be REACT strategy that is application of Context Based Learning.

It was decided that the activities and the practice developed and conducted for experimental group had been more effective than control group in terms of academic achievements of 6th grade students within the frame of curriculum objectives/gains. Most of the alternative concepts possessed by learners were replaced by scientific facts and constructed accurately (1,2,7,12,15) while some of them were somewhat affected (3,4,5,11,13). Some of the alternative concepts remained the same (8,10) while some of them rose at the end (6,9,14). Taking into account the results of the implementation carried out with control group, it is seen that they did not experience a decrease as much as experimental group. Therefore, it is possible to say that REACT strategy is more effective than 5E teaching model implemented by Ministry of National Education in terms of both academic achievement and conceptual change. This is because in the instructions employing context based learning, students should be made to feel that the subject is also a part of their lives. In the developed REACT strategy, bottled gas was used as context and the attention of students were tried to be raised.

Suggestions

In this study, REACT strategy was more effective than control group in terms of changing alternative concepts in relation to subject of particles making up the matter. But, it was revealed that learners have difficulty in envisaging the fact that there is space between particles forming the matter. Different conceptual change pedagogies can be designed and integrated into REACT strategy and tested for efficiency. Learners think that gases cannot be matters since they do not have volume and mass. Hence, different connections and visual materials can be developed to enable learners to construct states of matters with particular

importance to properties of gas state. Simulations and animations can be used to assist learners when they fail to imagine. Visual materials can be designed to teach abstract concepts which they do not make sense and encounter in daily life. Within the frame of current implementation, it was not questioned to what extent this learning was permanent. Besides, the learners were not interviewed clinically in relation to alternative concepts. Thus, data variety and reliability can be increased by performing interviews in addition to current implementation with a new sample that may yield different results.

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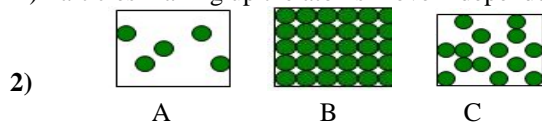
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Appendices

App. 1: AAT questions

- 1) A student read in a newspaper that tiny particles making up the atom are used to treat some disorders. The student reading this **can** infer that
- Cells are made up of atoms.
 - Atoms can be divided.
 - Atoms are everywhere in matters.
 - Particles making up the atoms move independently where there is no matter.



The figure above show granular structures of matters differing from each other. There are some statements in relation to these matters below. Which of them is **incorrect**?

- Matter A may be water vapor, matter B may be water and matter C may be ice.
- Matter A does not have a certain volume but it takes the volume of the cup it is in.
- Matter C has a certain volume and it takes the shape of the cup it is in.
- Matter B has a certain volume but it does not take the shape of the cup it is in.

- 3) An idea occurs to Kağan's mind while eating nuts and he wants to implement it. He takes a press and puts nuts in it. He tries to pure them but realizes that they do not divide into tiny pieces. He wants food processor from his mother and this processor makes nuts powdery.

To you, **what is the purpose** of Kağan with this experiment?

- He proved that solid matters are more easily fragmented than gases.

- B) He wanted to divide into tiny pieces to compress the nuts.
 C) He questioned to what extent matters can be successively divided.
 D) He wanted to increase the space between particles making up the matter.

4)



I II III

The figures above shows the order of particles making up matters in three different physical states. Considering the spaces between particles, choose the **correct** matching below.

- | | I | II | III |
|----|-------|-------|-------------|
| A) | Apple | Peach | Air |
| B) | Peach | Apple | Soup |
| C) | Milk | Table | Cloud |
| D) | Table | Milk | Water vapor |

5) X and Y matter of the same quantity are put into identical cups having pistons. When equal force is applied on both pistons, it is seen that matter Y is compressed while matter X is not.

Based on this observation, which of the statements below is **true** for the particles making up matter X and Y?

- A) Matter X has integral structure while matter Y is granular.
 B) The space between particles making up the matter Y is bigger.
 C) There is no space between the particles making up the matter X.
 D) The space between particles making up the matter X and Y is the same.

6) If a researcher thinks that particles of different types of matters are different from each other, **which** of the ideas below should be implemented by him?

I- He should compare the particle models of three different matters.

II- He should divide a matter he takes in his hand as many as he can.

III- He should compare models of solid, liquid and gase particles making up a matter.

IV- He should examine an animal cell with a microscope.

- A) Only I B) Only IV C) I and III D) II and IV

7) Ayşe knows that the word atom means indivisible and she made a research about atoms. Which of the following statements **cannot** be one of her explorations?

- A) Building stones making matters which are different from each other are called atoms.
 B) Atom is named by Democritus.
 C) Atom means indivisible.
 D) Atoms are impossible to divide and break.

8) Which of the following statements is **correct**?

- A) If we cannot see tiny particules of a matter which are hard to divide, this means there is no matter at all.
 B) All kinds of matters are comprised of building stones which are too tiny to be seen.
 C) Undivided tiny particles of only solid and liquid matters can be seen.
 D) Even if gases are not seen, they are comprised of tiny particules which can be seen via microscope.

9)



Which of Ayşe's statements about atoms is **correct**?

- A) Atoms are building stones of the matter similar to globes.
 B) Atoms can be seen via microscopes.
 C) Atoms transform as well while matters make transition from one state to another.
 D) All matters are comprised of the same atoms.

10) Nazlı first dripped a drop of milk into a glass of water. She realized that the color of the water did not change after she mixed it. Later, she dripped a drop of tea and again observed that the color did not change.

Which of the following statements is **irrelevant** to what Nazlı has tried to do?

- A) Atoms making up the milk and tea diffuse in water.





- B) No change occurs in atom sequence of milk and tea particles.
 C) Nazlı might have tried to prove that matters are made up of unseen particles.
 D) If Nazlı had mixed tea with water before milk, the color of water might have been changed.

11) Zeynep left solid balls of naphthalene in the closet to keep the pests away. After a few weeks passed, she realized that the balls were gone. However, there was a heavy odor of naphthalene in the closet. To you, **why** Zeynep did not see balls of naphthalene even though there was the smell of it?

- A) That is because solid balls of naphthalenes disappear after a few days.
 B) If Zeynep cannot see naphthalene, that means there is no naphthalene.
 C) That is because matters are formed of tiny particules which are unseen.
 D) If Zeynep had looked more carefully, she could have seen gas particles of naphthalene.

App. 2: CT questions

- 1) Four friends are discussing about atoms. To you, which statement is correct?

- A)  → Atoms are animate due to their movements.
 B)  → Atoms of living beings are animate while atoms of non-living things are inanimate.
 C)  → Atoms of objects with different shapes are different even if they are made of the same material.
 D)  → Matters are comprised of atoms and these atoms are inanimate.
 That is because

.....

- 2) Which of the following statements in relation to matters is correct?

- A) There are atoms between the particles making up the matter.
 B) A matter can be divided until there is nothing left.
 C) Atoms making up the matter are colorless.
 D) If the matter is unseen, then there is no matter.

That is because

.....

- 3) Which of the following statements in relation to atoms is correct?

- A) Scientists saw the atom.
 B) Atoms are flat and there is another substance between them.
 C) Atoms have a simple cycle within a circle.
 D) Our cells are comprised of many atoms.

That is because

.....

- 4) Which of the following statements is correct?

- A) Air is not a matter since it does not have volume and mass.
 B) Gases do not have masses.
 C) Air is not a matter since it is unseen.
 D) Particles making up the solid, liquid and gaseous matters are colorless.

That is because

.....

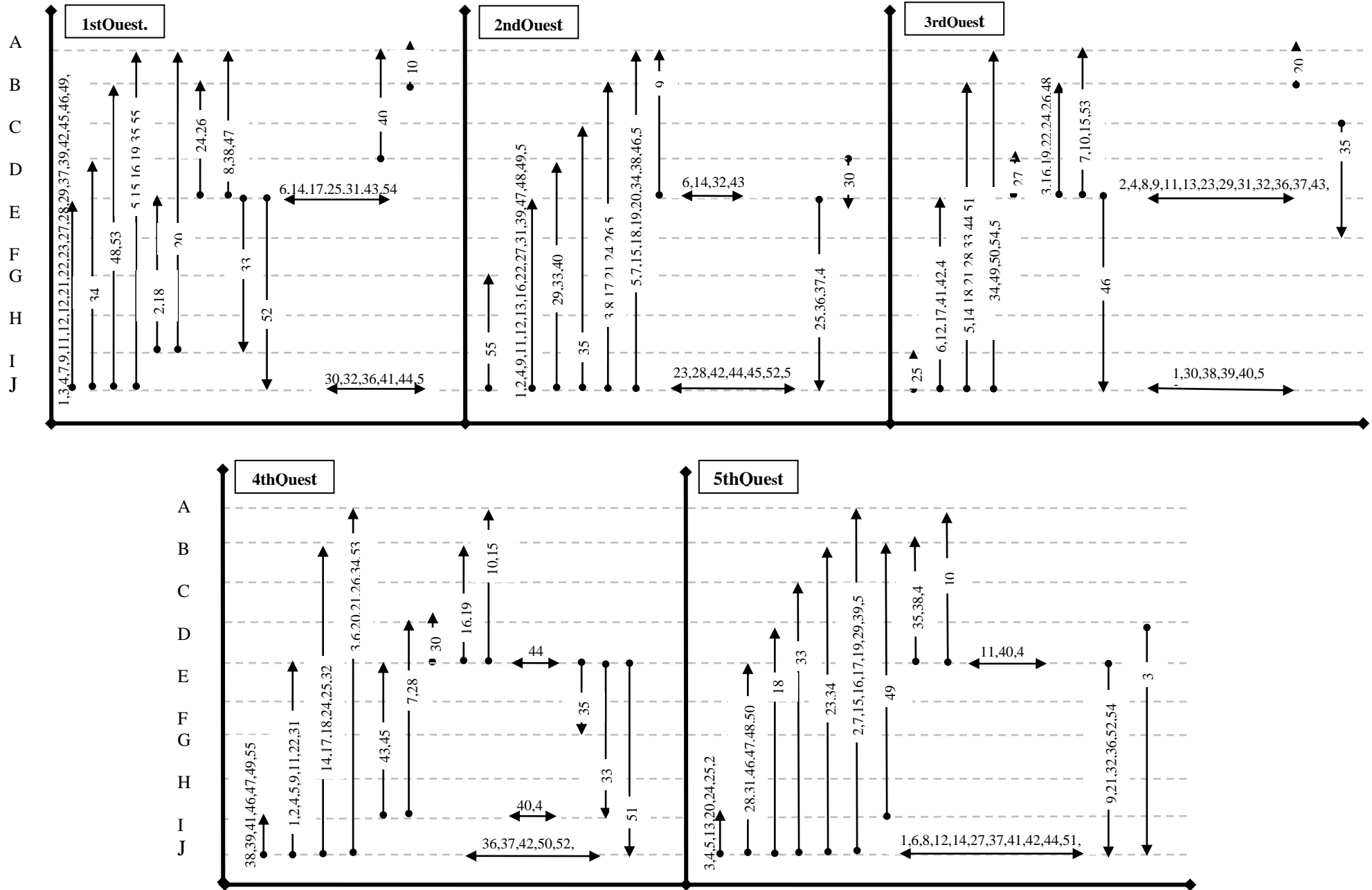
- 5) Which of the following statements is correct?

- A) Atom is similar to a globe with its components.
 B) There is air between particles making up the matter.
 C) Atoms are big enough to be seen by means of a microscope.
 D) There are tinier particles making up the atoms.


That is because

.....

App. 3: Classification of learner responses given to two-stage questions in CT (experimental group)



Analysis of Pre-Service Physics Teachers' Understanding of Vectors and Forces

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Received: 13.06.2016

Revised: 14.11.2016

Accepted: 01.12.2016

The original language of article is English (v.14, n.2, June 2017, pp. 82-95 , doi: 10.12973/tused.10200a)

ABSTRACT

The aim of this study is to analyze the ability of students to understand vectors as well as force concepts. Survey study was implemented in this study to obtain detailed information of students' ability and involved 212 physics education students of Tanjungpura University who have completed Basic Physics course. They were asked to solve tests of vector and tests of force adapted from physics education research group. Test of vector (TUV) consists of 13 items and covers addition, subtraction, and component. Furthermore, test of force (TOF) that has nine items covers three different contexts - horizontal surface, inclined plane, and pulling the rope. The results show that (i) students answer correctly 56% of TUV and 46% of TOF, (ii) subtraction concept is the most difficult for students to solve vector test and inclined plane is the lowest percentage done correctly by students in force test, and (iii) the correlation between students' ability of vector and students' ability of force is 0,304 ($p = 0.01$) with moderate category. This indicates that one of factors that can affect student's performance in solving force concept is vector skills. Hence, before students starting learning force concept, teachers can administer vector test to elicit students' prior knowledge of vector.

Keywords: vector, force, and free body diagram

INTRODUCTION

Newton's law of motion deals with force, and is a core concept in basic mechanics, usually taught as part of physics from secondary school to university level (Savinainen, Makynen, Nieminen, & Viiri, 2013). Besides mechanics, force is also taught in the topics of electrostatics and magnetism, etc; therefore, force is an essential concept in physics (Özdemir, 2015). However, students generally struggle to grasp the concept of force (Maloney, 1990; Savinainen, Scott, & Viiri, 2005; Bozdoğan & Uzoğlu, 2015). For example, students often do not have a clear understanding of the meaning of force (Palmer, 1997). They are also unable to differentiate between force, inertia, energy, power and even velocity. In addition, many students perceive that force simply influences an object's motion (Minstrell, 1982). For example, gravity is not a force, but simply 'what makes it fall' (Knight, 2004).



Physics education research has investigated and promoted ways to improve the understanding of students, from senior high school to college level, about force (Thornton & Sokoloff, 1998; Savinainen & Scott, 2002; Nieminen, Savinainen, & Viiri, 2010; Önder et al., 2013). Researchers have also made studies of drawing a diagram of force (Free Body Diagram (FBD)). Rosengrant, Etkina, and van Heuvelen (2009) explain that a Free Body Diagram (FBD) is a diagrammatic representation that depicts some object of interest and the forces exerted on it by other objects. They propose six steps for drawing an FBD, in an effort to help students solve force problems. Their study found that the majority of students who used FBDs felt them to be helpful when doing exams. Also, students who drew diagrams correctly were significantly more successful in answering questions than those who did not. However, their study still has limitations qualitatively: the students only solved one problem. Hence, another investigation is required on whether using FBDs can improve students' grades. Other factors, such as mathematical skill, may also play a part.

A study has also been made on using Interaction Diagrams (ID) – representing interaction between objects – to help students in identifying forces when constructing FBDs (Savinainen et al., 2013). They found that students using IDs outperformed those not using IDs in identifying forces and constructing FBDs. They claim that IDs can help students to perceive force as a property of an interaction rather than of an object. They also investigated the effect of teachers' instruction on using IDs in teaching Newton's law. However, the correct identification of interacting objects in an ID did not always result in correct force identification, especially in the light group (not using IDs), and students could correctly construct FBDs even when their ID skills were low. This shows that in understanding the concept of force, students do not only need to know about FBDs and IDs, but also to have a sufficient grasp of the concept of vectors to construct a force diagram.

A number of researchers (Aviani, Erceg, & Mesic, 2015) have conducted research focusing on university students, by implementing two different approaches to drawing free body diagrams. They have analyzed the effect of these methods—superposition and decomposition—regarding students' understanding of Newton's laws, as well as regarding their ability to identify real forces. The decomposition method refers to the determination of a vector's components, followed by finding the resultant of the vector. By contrast, the superposition method refers to adding vectors, while placing the tail of a vector to the previous vector. It has been found by these researchers that many students lack the ability to distinguish amongst real forces, forces components and force resultant. Furthermore, it was found that students have an understanding that forces and their components act on a body independently and simultaneously. This means that students do not only understand force concepts, but also have developed mathematical skills, such as those involved in a vector. Flores, Kanim, and Kautz (2004) have argued that students should be aware that learning about Newton's law requires an understanding of vector concepts.

In physics, *vector* is defined as a quantity with both a magnitude and a direction (Arons, 1997). For example, velocity is a vector, as it describes both how fast an object moves and in what direction it moves. Most physical concepts involve vectors, such as acceleration, force, momentum, etc. (Serway & Vuille, 2012). Hence, vector is a very important skill for students to acquire, while studying physics (Knight, 1995). In Indonesia's physics curriculum, vector is usually taught from senior high school until university level.

However, students still struggle to understand physics material during their first year at university, even though all students begin learning physics in senior high school (Haratua & Sirait, 2016).

Studies about vectors have also been undertaken by educational researchers in physics. Nguyen and Meltzer (2003) have investigated students' understanding of vectors in introductory courses in physics. They found that more than 50% of students were not able to solve two-dimensional vector additions. Many students lacked understanding about vector direction and were confused about tip-to-tail and parallelogram addition rules. Flores et al. (2004) found that about half of the students attending introductory classes could not correctly determine the resultant of vector by the adding method. Subtracting two vectors was the most difficult task for students, when asked in the context of working on qualitative problems. Knight reached a similar conclusion (1995), arguing that only about 30% of students are able to provide an adequate definition of vector. Less than 50% of undergraduate students answered correctly regarding the vector addition problem, while presenting it in an arrow format.

Furthermore, Barniol, and Zavala (2014) also conducted research about vectors (vector test), by comparing the understanding of students who solved problems with no physical context, with those who solved problems with a mechanical context. The results showed that there was no significant difference between the number of items solved correctly by students with no physical context, compared to those with a mechanical context. However, they found significant differences in some items, and the ability of students who had learned calculus-based mechanics relied on the type of context. Rakkapao, Prasitpong, and Arayathanitkul (2016) undertook a study focusing on the notion of vector, by employing a vector test designed by Barniol and Zavala. The results showed that most students were not able to differentiate between adding and subtracting two vectors. Once two vectors are presented in an opposite direction, students tend to directly add them, even if being asked to subtract them.

Having a good understanding of basic vector concepts is helpful for students to grasp the concepts of physics. For example, Shaffer and McDermott (2005) identified students' difficulties (undergraduate students, graduate students, and pre-service teachers) in understanding velocity and acceleration of pendulum bob as vectors, in one and two dimensions. Based on their research, they developed some instructions, by connecting vector skills and concepts from kinematics, helping students' learning in an introductory physics course. They were able to help students analyze motion in one dimension and transfer to two dimensions, by using vectors. Bollen, van Kampen, Baily, and De Cock (2016) investigated students' difficulties in an electrodynamic course, by using vector calculus. Students were not able to understand vector operators in solving Maxwell's formula. Based on their difficulties, these researchers helped students understand the concept of electromagnetism, by designing, implementing and evaluating instructions.

These findings indicate that having a good understanding of vectors is very important when it comes to learning physics. The purpose of this research includes: 1) analyzing students' understanding of vectors, as well as force concepts, comparing students at different levels; 2) establishing the relationship between students' understanding of vectors and their ability to grasp force concepts.

METHODOLOGY

a) Model of the research

The major purpose of a survey is to describe various aspects and characteristics of a concept, such as the abilities, opinions, attitudes, beliefs and / or knowledge of a specific population (Fraenkel & Wallen, 1993). In the case of this study, a survey was conducted with an aim to obtain detailed information about students' ability to understand vector and force concepts.

b) Population and Sample

Participants in the study consisted of 212 pre-service physics teachers—from the first, second and third year—who had taken a basic physics course at the Teacher Training and Education Faculty of Tanjungpura University (59 males and 153 females). Students graduating from this faculty then tend to teach physics at the middle and senior high school levels.

Table 1. *Description of the participants*

| Students | Male (N) | Female (N) | Total |
|-------------|----------|------------|-------|
| First Year | 20 | 55 | 75 |
| Second Year | 24 | 62 | 86 |
| Third Year | 15 | 36 | 51 |

c) Data Collection Tool

To obtain data, we adapted an existing test—the Vector and Force Test—from the Physics Education Research group (Nguyen & Meltzer, 2003; Barniol & Zavala, 2014; Heckler & Scaife, 2015; Aviani et al., 2015). This test was translated from English into Bahasa Indonesian, by translators working at the science education department. We then chose items based on our needs for this research and designed a number of other items to complete the test. Afterwards, five faculty members of the physics department validated the items. They were asked to rate each item with a score from one to four, to measure how well the test items addressed physics content. The reliability of both tests was determined by using a statistical analysis (Ding, Chabay, Sherwood, & Beichner, 2006). Validation and reliability are needed to obtain a good test (Faize & Dahar, 2012). There are two tests with multiple-choice items used in this study: one is the test of vector (TUV) and the other is the test of force (TOF). Multiple-choice tests are powerful when it comes to examining students' understanding, because they are easy and economical to administer and grade and their scoring is objective (Singh & Rosengrant, 2003; Ding & Beichner, 2009). TUV consists of thirteen items, covering addition, subtraction and component; this was used to measure students' understanding of vectors. Meanwhile, TOF consists of nine items with different contexts—horizontal surface, inclined plane and pulling the rope—examining students' ability in free body diagrams. The two types of test were administered to students, in order to establish their understanding about vectors and force. Students were given one hour to solve both tests (twenty minutes for TUV and forty minutes for TOF).

Table 2. Number of items of each test

| TUV | | | TOF | | |
|----------|-------------|-----------|--------------------|----------------|------------------|
| Addition | Subtraction | Component | Horizontal surface | Inclined plane | Pulling the rope |
| 4 | 3 | 6 | 4 | 3 | 2 |

d) Data Analysis

To establish students' understanding about vectors and forces and the correlation between them, we first tabulated students' answers for every item, with options for both tests. We then statistically analyzed (Moore, McCabe, & Craig, 2012) the students' answers, looking for example at the percentage of students answering the test correctly, divided into four categories (<25%, 25%-50%, 50%-75%, and >75%), as well as looking at the students' performance for each test, their performance for every concept and context, and the correlation between students' ability in solving vector and force. We used SPSS 24 (Statistical Package for Social Sciences Program, Version 24) to analyze the data.

FINDINGS

The details of the statistical analysis of both tests are presented in Table 3. The difficulty index of the vector test and the force test measuring the proportion of students who answered correctly was 0.55 and 0.46, respectively. These values are between 0.3 and 0.9, as an appropriate range of the difficulty index. For students, these values indicate that the vector test is easier than the force test. Furthermore, the average of the discriminatory index in both tests is above 0.3. This number is appropriate for the discriminatory index criteria. The self-consistency of the whole test was also determined by using the Kuder-Richardson analysis. It found that the reliability indexes of TUV and TOF are 0.75 and 0.70 respectively.

Table 3. Summary of statistical analysis

| Test statistic | Desired values | TUV values | TOF values |
|------------------------------------|----------------|---------------|---------------|
| Item difficulty index | ≥ 0.3 | Average: 0.55 | Average: 0.46 |
| Item discrimination index | ≥ 0.3 | Average: 0.37 | Average: 0.36 |
| Kuder-Richardson reliability index | ≥ 0.7 | 0.75 | 0.70 |

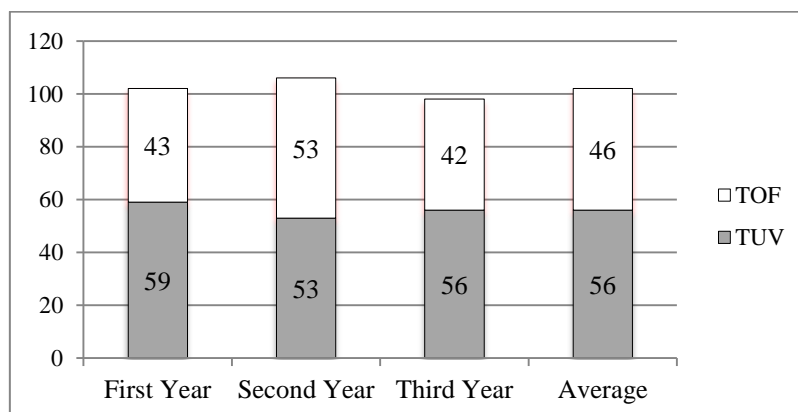
For the purpose of analyzing the students' understanding of vectors and forces, we looked at answers from all 212 students who completely solved both tests, the TUV and the TOF. The results regarding students' understanding of vectors and forces are shown in Table 4. The percentage of students who solved more than 75% (ten to thirteen items) correctly on the vector test was 22%. The third-year students were more successful in solving more than 50% of the TUV, than first and second-year students were. The percentage of students in the third year who could solve correctly more than a half of the vector test was 61%, while the percentage in the first year was a little bit lower (60%). However, only 54% of second year students were able to answer more than 50% of the items (seven to thirteen items).

Table 4. *Percentage of students who solved the test correctly*

| Students | TUV | | | | TOF | | | |
|-------------|---------------|------------------|------------------|-----------------|---------------|------------------|------------------|---------------|
| | <25% (1-3) | 25%-50% (4-6) | 50%-75% (7-9) | >75% (10-13) | <25% (1-2) | 25%-50% (3-4) | 50%-75% (5-6) | >75% (7-9) |
| First Year | 7 | 33 | 31 | 29 | 32 | 28 | 28 | 12 |
| Second Year | 10 | 35 | 38 | 16 | 20 | 23 | 29 | 28 |
| Third Year | 12 | 27 | 39 | 22 | 25 | 39 | 27 | 8 |
| Average | 10 | 32 | 36 | 22 | 26 | 30 | 28 | 16 |

There was a difference when it came to the force test. Sixteen percent of students successfully answered more than or equal to seven to nine items ($> 75\%$) in the force test. Second-year students achieved a higher percentage and solved correctly more than 75% of the force test (seven to nine items), followed by students in the first and third year. However, when it came to five to six items (50-75%), there was no significant difference in the percentage of students; the difference was only found to be 1%.

The percentage of tests solved by students is presented in Figure 1. Students' ability to answer the TUV was 56%. The median was seven (out of thirteen), meaning that students who were on the median in the test had some difficulty answering six items correctly, whereas students' performance on the TOF was 46%, with most students being able to solve five to six items correctly.

**Figure 1.** *Percentage of problems solved by students*

a. Vector

The test of Vector (TUV) consists of thirteen items and three concepts: addition, subtraction and component. Table 5 depicts the proportion of students correctly answering all items (bold font is the correct answer). Vector addition comprises of four items that are in one and two dimensions. Most students were able to solve the vector addition correctly in one dimension (items one and four); 96% of students were able to answer item one correctly, while 79% were able to answer item four. Two-dimension (2D) was the most difficult concept for students, as only 25% of them were able to solve both items (items seven and ten) correctly.

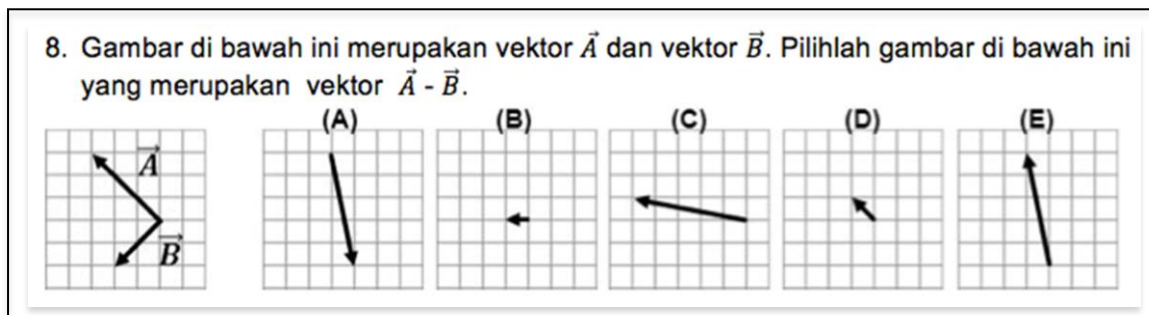


Figure 2. Question number 8 of the vector test (Indonesian version)

Vector subtraction consists of three items (two, five and eight), with two items in one dimension and one item in two dimensions. Sixty four percent of students correctly answered vector subtraction with the same direction (parallel), while only 43% of students were able to correctly solve these when given a different direction (anti-parallel). Moreover, vector subtraction with two dimensions was found to be the most difficult for students; only 21% of students correctly answered this item. Figure 2 shows the vector subtraction problem (item eight) in two-dimensional form.

Students' performance seems to be better in the vector component, than it is in the addition and subtraction vector. Students answered more than 50% of each item group correctly. Furthermore, 62% of students were able to determine the direction and magnitude of vector components. Most students (73% of them) seemed to be able to successfully identify the x and y components of a vector.

Table 5. The description of items and the percentage of students' answers on TUV

| Concept | Item | A | B | C | D | E |
|-------------|------|-----------|-----------|-----------|-----------|-----------|
| Addition | 1 | 3 | 0 | 1 | 96 | 0 |
| | 4 | 79 | 5 | 5 | 10 | 0 |
| | 7 | 10 | 14 | 2 | 49 | 25 |
| | 10 | 10 | 20 | 6 | 39 | 25 |
| Subtraction | 2 | 4 | 5 | 26 | 64 | 1 |
| | 5 | 3 | 45 | 6 | 43 | 3 |
| | 8 | 33 | 11 | 11 | 24 | 21 |
| Component | 3 | 6 | 8 | 73 | 8 | 4 |
| | 6 | 15 | 7 | 8 | 69 | 2 |
| | 9 | 30 | 51 | 5 | 2 | 11 |
| | 11 | 8 | 8 | 66 | 12 | 6 |
| | 12 | 13 | 12 | 6 | 67 | 1 |
| | 13 | 3 | 8 | 48 | 36 | 5 |

Figure 3 shows a histogram of students' achievement (students with different levels) in terms of solving tests of vector with three concepts—addition, subtraction and component. Students appeared to have some difficulty in solving additions and subtractions. It can be seen in the histogram that students were only able to correctly solve 42% of subtraction problems (the average score was 1.26 out of three possible points). Meanwhile, the addition concept was a little higher than subtraction; nevertheless, it was found to be lower than the component concept. This trend shows that first year students achieved higher scores for every concept than students in the second and third year did.

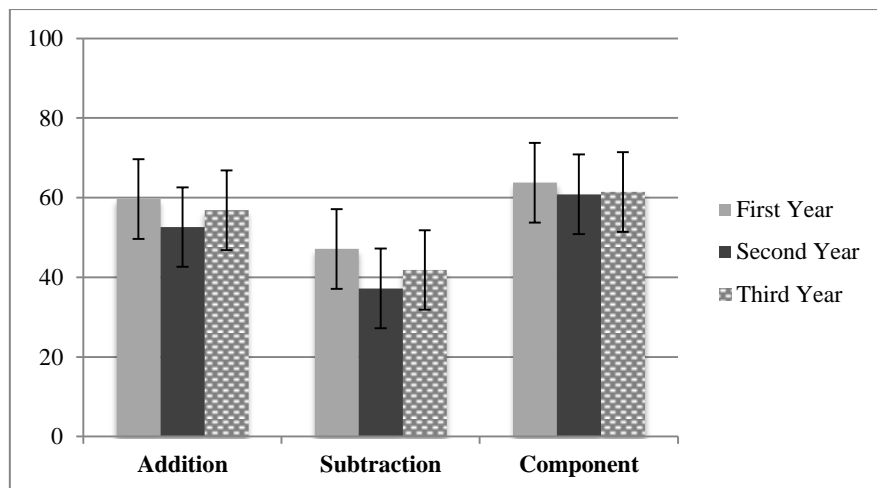


Figure 3. Students' performance solving TUV

b. Force

Table 6 presents the distribution of students' answers for every question item in the context of the force. The answers are interpreted by percentages, in which the bold font represents the correct answers. It can be clearly seen that the choice of every question item varies considerably across the context of force and students made mistakes in every context. Most students (83%) successfully answered item one: a block rests on a horizontal surface; students were asked to choose to correct free-body diagrams. However, in item two (a force acting on an object, while the object remains at rest), students had difficulties answering the problem. Students did not notice the force component. Furthermore, some students seemed to lack the ability to identify a free-body diagram, while an object moves with constant speed and constant acceleration (items three and four).

On the inclined-plane context, more than 50% of students were not able to provide correct answers to the problems. Students only understood the real forces on an object without thinking about vector components (why the object does not move on an inclined plane). In addition, when an object moves with constant speed and continuous acceleration, they were not able to correctly distinguish free-body diagrams for every situation.

Table 6. The description of items and the percentage of students' answers on TOF

| Context | Item | A | B | C | D | E |
|--------------------|------|-----------|-----------|-----------|----|-----------|
| Horizontal Surface | 1 | 12 | 2 | 83 | 2 | 1 |
| | 2 | 22 | 9 | 33 | 34 | 2 |
| | 3 | 11 | 6 | 27 | 15 | 40 |
| | 4 | 52 | 16 | 10 | 13 | 9 |
| Inclined Plane | 5 | 4 | 40 | 18 | 7 | 31 |
| | 6 | 16 | 42 | 23 | 10 | 8 |
| | 7 | 55 | 15 | 10 | 7 | 13 |
| Pulling the rope | 8 | 50 | 36 | 1 | 7 | 5 |
| | 9 | 14 | 3 | 24 | 8 | 52 |

The percentage of students correctly answering the problems regarding pulling the rope context was more than 50%. They did not completely identify all the forces exerted on

an object, such as the normal force and the gravitational force. Consequently, students were not able to successfully choose the right force body diagram on the object.

The ability of students from three different years to solve force tests is displayed in Figure 5. Based on the histogram, the lowest percentage of students' performance (41%) solving TOF was in inclined context. The average score was 1.23 out of three possible points. Students faced difficulties understanding free-body diagrams on an object, when moving with constant velocity and acceleration. Moreover, when students analyzed the rope problems, they did not include gravitational force and normal force.

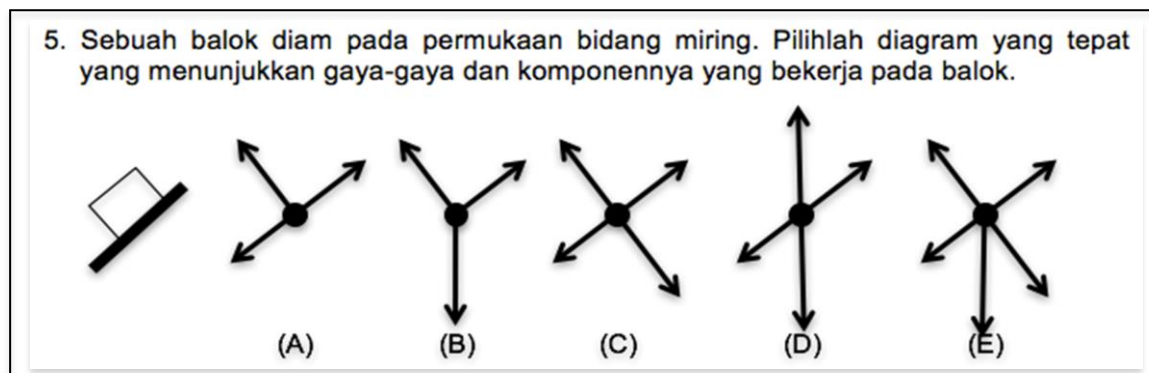


Figure 4. Question number 5 of force test (Indonesian version)

Relationship between Vector and Force

Based on the conducted correlation analysis, overall, the correlation between students' skills of vector and students' skills of force was found to be 0.304 (SD of vector was 22.3, while SD of force was 26.3, and $p = 0.01$). This value is moderate category. This means that there is a positive correlation, implying that students who have high skills in vector will achieve good performance in force. Furthermore, the correlation of students' performance on the vector component and force test was also established. The correlation is 0.325 (SD of vector is 28.3, SD of force is 26.3, and $p = 0.01$); therefore, it can be concluded that in order for students to successfully grasp force concepts, they first have to master vector concepts.

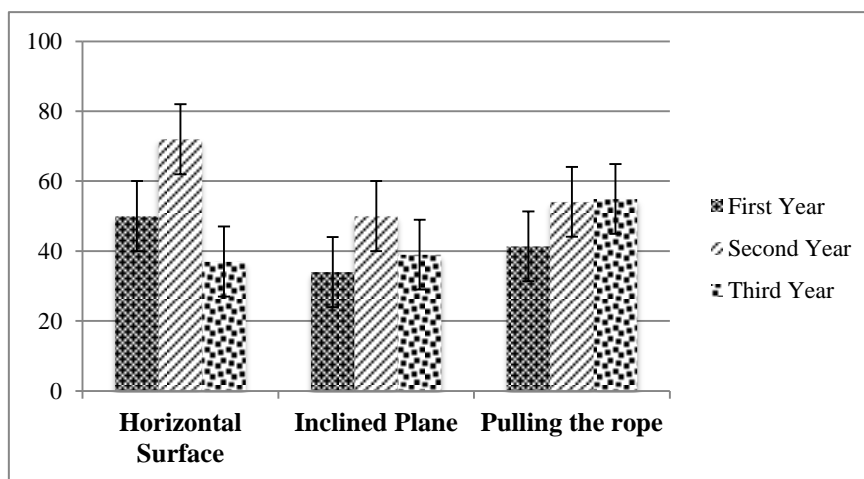


Figure 5. Students' performance solving TOF

DISCUSSION

In this study, we have presented three findings regarding pre-service physics teachers' understanding of vectors and forces. Most students were able to correctly answer vector additions with the same direction (parallel) and also with opposite direction (anti-parallel) in one dimension. However, students seemed to lack the ability to determine the resultant of two vectors, when presented in two dimensions. This finding is similar to findings by Barniol and Zavala (2014) and Nguyen and Meltzer (2003). Students tended to draw a line from the head of one vector to the head of the other vector. Students did not seem to notice the basic rule (head-to-tail method and Pythagorean theorem), in terms of how to sum vectors with two dimensions.

Furthermore, the subtraction concept is the most difficult one for students to grasp; more than half of the students were not able to solve subtraction problems. For example, students tended to subtract opposing arrows (one dimensional) incorrectly. Based on the students' answers, they were able to reach similar conclusions when it comes to vector addition. The most difficult aspect for students is to subtract two vectors in two dimensions. The students did not seem to be aware of the minus sign of the vector. Consequently, they tended to subtract two vectors, by using the addition method. This means that students do not have adequate abilities to sum and subtract vectors, while presented in two dimensions (Van Deventer & Wittman, 2007). Heckler and Scaife (2015) found that students found it easier to solve vector problems, when they were presented in $i j k$ format, rather than when presented in arrow format. This suggests that students should be presented with various formats, when learning about the vector concept. Students do not only need to be taught how to successfully use mathematical tools, such as vector, while solving physics problems; they also need to learn how to interpret these tools and give meaning to them (Redish & Kuo, 2015).

The vector component was found to be more successfully attempted by students. The vector component measures students' understanding in terms of how to determine x and y component vectors. Students simply draw a line from the head of the vector to the x and y-axis. However, when students were asked to determine the magnitude of the vector component in mathematical representations, they had difficulties in distinguishing *Sin* from *Cos* (trigonometry). This indicates that students were not able to completely understand the meaning of the vector component. As Redish and Kuo (2015) have stated, teachers should equip students with an ability to interpret mathematical equations, not just to use and memorize them. Overall, first-year students were able to achieve the highest score for every vector concept. This means that they were most successful in solving TUV. This was the result of students' having just learned the vector topic in the first semester.

The average ability of students when it came to understanding force concepts was found to be in the middle category; it was shown that students were able to correctly solve problems in almost half the tests. Students had problems in understanding the free-body diagram of an object on the surface, in terms of whether it was a flat or an inclined surface. They then were not able to fully identify the concepts of gravitational force, normal force, frictional force, and component of the force. Aviani *et al.* (2015) found that students cannot always successfully distinguish between real forces and their components. This finding indicates that students should be helped to fully comprehend the definition of force, that is,

the interaction between two objects. Students can use the interaction diagram in helping to draw a free body diagram (Savinainen et al., 2013).

Furthermore, students were not always able to identify a free body diagram of an object, while moving with constant speed and constant acceleration in a flat surface and an inclined plane. Most pre-service teachers were able to successfully determine the direction of velocity but were not able to establish the direction of acceleration of a pendulum bob, in terms of vectors (Shaffer & McDermott, 2005). Students should be helped to understand that the characteristics of an object can change its velocity (Redish, 2014). In this context, students must have enough skills in vector subtraction and addition, and they must also be able to distinguish between Newton's First and Second law. It seems that students are only aware of the equation of Newton's law: $\sum \vec{F} = 0$ and $\vec{a} = \sum \vec{F}/m$ (Tipler, 1991), without being aware how to determine the net force carefully, by using addition and subtraction methods. However, students can easily view force diagrams of an object placed on a horizontal surface, without external force exerted on it. Furthermore, on the inclined-plane, many students just chose the real force on the object, without noticing the component of each force. As a result, they had difficulties in determining a free-body diagram of an object, while at rest, moving with constant speed, and moving with constant acceleration. Rosengrant *et al.* (2009) argued that students who are able to draw the diagram correctly, will be able to reach the correct answer of the force problems.

In terms of the context of pulling the rope, students tended to solve the items correctly; a few students did not include external force—gravitational and normal force—in the system. Kuo, Hallinen, and Conlin (2015) have stated that a teacher should be careful prompting a force diagram, while solving problems in physics. Interestingly, the second-year students more successfully answered force tests than the first and third year students. This outcome might be affected by the fact that students in the second year had just learned about mechanics in a course covering equilibrium, rotational motion and fluids, all of which address the concept of force.

The correlation between the students' ability to solve TUV and their ability to solve TOF is in the moderate category. This means that there was found to be a positive relationship between vector skills and force skills. Students who scored highly in TUV also had high scores in TOF. Furthermore, students with a good understanding of addition and subtraction vector also seemed to have a good understanding of the concept of force, especially when it came to identifying free body diagrams.

Finally, in order to learn force concepts, this study suggests that students should not only have enough skills in drawing free-body diagrams; they should also be able to master vector concepts. Integration and making the link of multiple representations can help students learn the concept (Ainsworth, 2006; Li & Arshad, 2014). A physics teacher should focus on noticing how students perceive the use of vector in understanding the force concept and should on that basis design appropriate instructions for students who lack the ability to grasp vectors, as well as forces.

CONCLUSION

The analysis provided by the study shows that students who have learned the concept of vector remain challenged, especially when attempting subtraction vectors. Adding and subtracting two-dimensional vectors is very demanding for students. Meanwhile, when it comes to force problems, the ability to identify forces and the vector component, as well as the vector resultant, is one of the most crucial problems, especially in the inclined plane. As a result, students were not able to successfully identify an object while at rest, at constant speed and during acceleration. Based on the correlation between the vector and force tests, the results indicate that besides understanding the force concept, a factor that can affect students' performance in solving force problems is the ability to understand vectors (Flores *et al.*, 2004; Knight, 2004). This study suggests that students should devise vector concepts (addition, subtraction, component, and resultant) before learning about the concept of force.

ACKNOWLEDGEMENT

This work has been supported by a grant from The Ministry of Research, Technology, and Higher Education (KEMENRISTEKDIKTI) – Indonesia and Tanjungpura University. We also thank Teacher and Training Education Faculty, our colleagues, and students as parts of this study.

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Content Analysis of Stem-Focused Education Research in Turkey

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Received: 25.11.2016

Revised: 24.02.2017

Accepted: 20.04.2017

The original language of article is English (v.14, n.2, March 2017, pp.12-26, doi: 10.12973/tused.10195a)

ABSTRACT

This study conducted a content analysis for science, technology, engineering and mathematics (STEM)-focused studies in the field of education between 2014 and 2016 in Turkey. “Publication Classification Form” was used to analyze 34 articles identified in this context. The articles were examined by conducting content analysis including identity of the article, its subject, its methodology, its data collection instruments, its sample and data analysis methods. Based on the obtained data, it was determined that the most publications were made by scholars working in institutions such as the Ministry of National Education, Gazi, Sinop, Marmara and Middle East Technical University. It was also found out that qualitative method-based studies were the most prevalent in researches. In the analysis of the data, it was determined that descriptive analyzes were mainly performed, content and descriptive analyzes involving qualitative research methods were extensively used in the studies. It was concluded that analyzing the studies helped researchers make appropriate decisions about the research processes and observe trends in STEM-focused researches.

Keywords: Content analysis, STEM education, STEM research

INTRODUCTION

In this country, developments in all areas have gained a great impetus and developments in science, technology, engineering and mathematics have influenced almost every aspect of modern life. The necessity of integrating the many fields, such as science, technology, engineering, and mathematics, is an expected reflection of this situation to solve several problems we face in the globalizing age (Moore, et al., 2014). Therefore, quests have been initiated to enable individuals to pursue education in this direction (Kizilay, 2016). A new understanding called STEM, comprising the initials of the science, technology, engineering, and mathematics disciplines handled as a whole, has become popular. In this context, the reform efforts undertaken in recent years are shaped by the understanding of STEM, which is a remarkable indication of the importance given to these areas (NAE, 2010 & NRC, 2009).

STEM education is an integrated approach that embrace creative problem-solving techniques for students who will be innovators of the future (Roberts, 2012). STEM education prepares students to look at problems from an interdisciplinary point of view and gain knowledge and skills (Şahin, Ayar & Adıgüzel, 2014). Those who advocate an integrated



approach to STEM education argue that the interests, successes and motivations of the students would be increased with the topics involving real-world problems and ultimately the number of students pursuing careers in STEM fields would be increased (Honey, Pearson & Schweingruber, 2014).

STEM also has strategic priorities in terms of international competitiveness (Corlu, Capraro & Capraro, 2014, 74). Occupations in the STEM field can be considered “future professions” as they are required to drive technological innovation, economic growth, global competition, and the standard of living of a nation (Langdon, McKittrick, Beede, Khan & Doms, 2011, p. 6). The career awareness of students ought to be improved by early intervention in the education system if STEM-focused career choices of students are to be affected (Moore & Richards, 2012; Wyss, Heulskamp & Siebert, 2012). Building and developing an interest in STEM fields is of great importance in terms of students’ participations in the workforce in these areas in the future (Knezek, Christensen, Tyler-Wood & Periathiruvadi, 2013).

In this context, STEM, which directly affects the development of countries, has a very important role among the developments in the field of education (Kuenzi, 2008). STEM is regarded as the greatest educational movement of the last decade and support many ongoing educational movements (Daughterly, 2013). STEM education emphasizes a multidisciplinary approach to better prepare students for STEM disciplines and to increase the number of secondary school graduates choosing STEM professions. This indicates that the abbreviation STEM is far more than the naming of the four integrated disciplines (Ostler, 2012). It involves features such as technology-based materials development, visualization, experimentation, and data collection assistance. STEM education in principle seems to be a learning approach that integrates science, technology, engineering, and mathematics disciplines and skills and emphasize student-centered and collaborative learning (Israel, Maynard, & Williamson, 2013).

Thomasian (2011) states that STEM education has two main objectives. The first aims to increase the number of students who would choose a profession in these disciplines at the university level, and the second is to encourage students to apply creative solutions in their everyday lives to solve problems related to these disciplines by increasing the students’ level of basic knowledge in science, technology, engineering, and mathematics. Helping students to identify the connections between mathematics and science and occupational options is an important goal of STEM. There are some solutions that can be employed to increase the interest of young students in STEM professions. These are as follows: making projects planning and developing math skills, organizing summer camps or post-school programs to teach science to young people, ensuring the participation of students in mathematics and science clubs, providing opportunities for the exploration of technology, ensuring participation of students in science fairs, spreading the use of internet forums and social networking, and following the profession in science and engineering [State Educational Technology Directors Association (SETDA), 2008]. Experiential learning, practical activities, an integrative STEM education, and creative thinking communities are also possible ways to increase interests of students for STEM professions (Gallant, 2010).

Effective STEM education makes students active in science, technology, engineering, and mathematics applications. It is vital that STEM teachers have the knowledge of STEM, pedagogy, and technological pedagogical content for effective implementation of STEM education (NRC, 2009). These three features enable teachers to disseminate the best teaching of STEM disciplines that students can use in their daily lives and career choices (PCAST, 2010). According to the results of Caleon and Subramaniam’s study (2008) with 580 students in grades 5 and 6 in Singapore, 33% of the students were determined to be unsure about choosing science-related occupation. According to this proportion, it is possible to say that the

students do not have enough knowledge to influence their choice of STEM-related professions.

The integration of STEM fields, studied extensively abroad, and education given in schools where government policies are being developed in order to raise the workforce is not yet common in Turkey. In this context, there is a need to develop education policies and programs considering the needs of the country under the scope of entrepreneurship (STEM-Entrepreneurship, STEM+E), art/design (STEM-Art, STEAM), and computing (STEM-Computing, STEM+C) (Akgunduz and Ertepinar, 2015).

STEM has a strategic priority to protect our country's international competitive power and the reforms in this area have become especially important for Turkey's economic competition (Corlu, Capraro, & Capraro, 2014). One of the most important elements that will stimulate STEM-oriented educational movements in our country is academic research. In this context, so far, the number, quality, effectiveness and discipline of studies focusing on STEM-based education in our country are of importance. Establishing STEM-focused educational research would help us determine our route.

Educational research is known as the systematic recording, analysis, and publication of data encompassing research processes specific to education and gained through various methods (Mortimore, 2000). These studies have an important role to play in building theoretical foundations and developing policies in the education system. While some of these researches are the basis for educational reforms, others have shed new light with the findings obtained through analyzing previous studies on relevant literature. In this context, examining the existing researches and exploring their quality is of great importance in terms of providing information to researchers (Bacanak, Degirmenci, Karamustafaoglu, & Karamustafaoglu, 2011). Determining trends in the field is also important for the researchers to not only provide new insights but also guide the research processes and compare the results (Tatar & Tatar, 2008). Examining the researches using the content analysis method would be beneficial for the researchers to know the tendencies of the researches in the field, identify the research problems, shed lights on prospective researches, and avoid repetition of studies. In content analysis studies, it is seen that articles are examined mostly in terms of demographic part, research method, topic, and reference characteristics. Bilgin (2006) states that content analysis is employed to make sense of the discourse and avoid subjective factors in interpretation and describes it as a kind of communication psychoanalysis and communication perception art. Bardin (1977) states the content analysis includes the entire communication analyses, and objective and systematic methods are used to describe message contents. Berelson (1952) explains that content analysis is the objective, systematic, and quantitative description of the apparent content of communication.

When the national literature is examined, content analysis studies are found in the fields of education technologies (Gulbahar & Alper, 2009; Küçük et al., 2013), science education (Bacanak et al., 2011; Sozbilir, Kutu, & Yaşar, 2012), biology education (Ozay, Kose, Gul, & Konu, 2014), mathematics education (Baki, Guven, Karataş, Akkan, & Cakiroglu, 2011; Ciltaş, Guler, & Sozbilir, 2010), physics education (Onder et al., 2013), and chemistry education (Sozbilir, Kutu, & Yaşar, 2013; Sozbilir, 2013; Sozbilir, Kutu, & Yaşar, 2011; Sozbilir, Kutu, Yaşar, & Arpacik 2010) that form STEM disciplines. However, no content analysis studies were found for the articles on STEM-focused education in the national field. It is possible to find STEM-focused content analyses in the international literature (Brown, 2012; Jayarajah, Saat, & Abdul Rauf, 2014; Thomas & Watters, 2015; Yildiz Goktepe & Ozdemir, 2015; Jho, Hong, & Song, 2016)

Understanding the content of studies in the relevant literature would accelerate the integration of STEM-focused education. Having an idea about the research demographics, methodology and the topic is an important step in understanding this content. In this context,

relevant articles with the specified criteria were examined using content analysis of qualitative analysis methods and the answers to the following questions were sought.

1. What is the distribution of the identified articles by year and publication language?
2. What is the number of authors of the identified articles and their distribution by institutions they are affiliated with?
3. What is the distribution of the identified articles by the journals?
4. Which discipline was central for STEM in the identified articles?
5. What are the general trends in the research methods of the identified articles?
6. What are the commonly used data collection tools in the identified articles?
7. What are the commonly used samples and sample size in the identified articles?
8. What are the commonly used data analysis methods in the identified articles?

METHODS

This study is a descriptive content analysis research as it aims to describe STEM-focused published articles in the field of education and identify their trends. Descriptive content analysis is an effort involving a wide range of timeframe to describe and reveal trends and developments in researches in the field (Çalık ve Sözbilir 2014). Falkingham and Reeves (1998) also indicate that content analysis is a new method used for evaluating a collection of publications

a) Survey and Selection Criteria

The articles published in the period 2014–2016 on STEM-focused education studies in Turkey were selected with certain criteria and examined in terms of various variables. For this study indexes and journal databases such as the Educational Resources Information Centre (ERIC), EBSCO, Educational Journals @ ProQuest, Emerald, Science Direct, Scopus TM, Springer Link, Taylor Francis Online, Web of Science, Ulakbim and Google Scholar were searched. These indexes and journal databases were searched using key words such as STEM, STEM education, STEM in Turkey, Fetemm, Fetemm education, Fetemm in Turkey. Required criteria for the articles accessed from the indexes are as follows:

1. Being published in a national/international peer-reviewed indexed journal between 2014 and 2016. As STEM focused educational studies started about in 2014, studies conducted in these dates were included for this study.
2. The fact that study fields of the articles are from Turkey
3. Being STEM-focused research

In total, 34 articles were identified meeting these criteria.

b) Data Collection Tool

The “publication classification form” developed by Sözbilir, Kutu and Yaşar (2013) was used in the present study. A number of changes were made in this form before it was used to classify the articles. The publication classification form consists of six parts: descriptive information about the identity of the article, the topic of the article, method, data collection tools, sample and data analysis methods.

c) Data Analysis

The articles identified by the survey were reviewed in the following subheadings: “publication date,” “number of authors,” “author institution/institutions and department,” “publication language,” “STEM study fields (science, technology, engineering, and mathematics),” “sample of the study,” “sample size,” “method used in the study,” “data collection tools,” and “data analysis methods”. The researcher created a table covering these

sections and sub-dimensions of the sections in order to classify articles. The articles were classified by coding with another researcher who has at least a PhD degree and has taken a course of scientific research in order to increase the reliability of the articles. The related correlation was calculated by coding as 1 if the codes structured by two researchers were consistent and as 0 if they were inconsistent. The Pearson correlation coefficient between these codes was found to be .98, and differing codes were amended through discussion. The articles were analyzed with agreements of researchers. Afterwards, six randomly selected articles were coded by another researcher. It was determined that articles coded by researchers were 100% consistent.

FINDINGS

In this section, In the findings section of the study, analyses of the STEM-focused educational articles with different variables and the findings obtained were presented. In this context, research findings were given in terms of years and publication language, number of authors and distribution by universities, distribution by journals, topic distribution, method used, data collection tool, sample, and data analysis method. The frequency and percentage results were tabulated and interpreted.

Demographic Information Distributions of Researches

A total of 34 articles were identified in accordance with the determined inclusion criteria from STEM-focused educational studies published between 2014 and 2016 in Turkey.

a) Distribution of Studies by Years and Study Language

Distribution of publication years and the study language of the identified articles were shown in Table 1.

Table1. *Distribution of studies by years and frequency and percentages of study language*

| | Turkish | | English | | Total | |
|-------|--------------|----------------|--------------|----------------|--------------|----------------|
| | Frequency(f) | Percentage (%) | Frequency(f) | Percentage (%) | Frequency(f) | Percentage (%) |
| 2014 | 3 | 8.8 | 5 | 14.7 | 8 | 23.5 |
| 2015 | 1 | 2.9 | 7 | 20.5 | 8 | 23.5 |
| 2016 | 3 | 8.8 | 15 | 44.1 | 18 | 53 |
| Total | 7 | 20.5 | 27 | 79.4 | 34 | 100 |

On examining Table 1, it is seen that 3 Turkish (8.8%) and 5 English (14.7%) articles in 2014, one Turkish (2.9%) and 8 English (20.5%) articles in 2015 and three Turkish (8.8%) and fifteen English (44.1%) articles in 2016 were published. The highest number of publications was 18 (53%) and 27 (79.4) that were in English.

b) Number of Authors of Studies

The articles were grouped according to the number of authors and the number of researchers for each research was determined. The number of authors is presented in Table 2.

Table 2. *Author numbers of studies*

| Number of Author | Article Number(f) | Percentage(%) |
|------------------|-------------------|---------------|
| 1 | 9 | 26.5 |
| 2 | 11 | 32.4 |
| 3 | 9 | 26.5 |
| 4 | 4 | 11.7 |
| 5 | 1 | 2.9 |
| Total | 34 | 100 |

Table 2 shows that eleven publications (32.4%) had with 2 authors, 9 publications (26.5%) had one author, and 9 publications (26.5%) had 3 authors.

c) Author Institutions of Studies

The distribution information of institutions of authors is given in Table 3.

Table 3. *Author Institutions of Studies*

| Universities/Institutions | Frequency (f) | Percentage(%) |
|---|---------------|---------------|
| Gazi University | 7 | 9.9 |
| MoNE (Ministry of National Education) | 7 | 9.9 |
| Sinop University | 6 | 8.6 |
| Middle East Technical University (METU) | 5 | 7.1 |
| Marmara University | 5 | 7.1 |
| Overseas Universities | 4 | 5.6 |
| Recep Tayyip Erdoğan University | 4 | 5.6 |
| Aksaray University | 3 | 4.2 |
| Karadeniz Technical University (KTU) | 3 | 4.2 |
| Bilkent University | 3 | 4.2 |
| Boğaziçi University | 2 | 2.8 |
| Kafkas University | 2 | 2.8 |
| Muş Alparslan University | 2 | 2.8 |
| Ondokuz Mayıs University | 2 | 2.8 |
| TÜBİTAK | 2 | 2.8 |
| Uludağ University | 2 | 2.8 |
| Erciyes University | 1 | 1.4 |
| Abant İzzet Baysal University | 1 | 1.4 |
| Anadolu University | 1 | 1.4 |
| Atatürk University | 1 | 1.4 |
| Bahçeşehir University | 1 | 1.4 |
| Giresun University | 1 | 1.4 |
| İstanbul Aydın University | 1 | 1.4 |
| İstanbul Ticaret University | 1 | 1.4 |
| Kocaeli University | 1 | 1.4 |
| Osmangazi University | 1 | 1.4 |
| Pamukkale University | 1 | 1.4 |
| Yüzüncüyıl University | 1 | 1.4 |
| Total | 71 | 100 |

Table 3 shows that examined large and advanced institutions such as Ministry of Education (MoE) and Gazi University with 7 authors (10%), Sinop University with 6 authors (8.6%), Marmara University and METU with 5 authors (7.1%) are leading.

d) Journals in which articles were published

The distributions of national/international indexed peer-reviewed journals are given in Table 4.

Table 4. *The Distribution of Journals in Which Articles Were Published*

| Universities/Institutions | Frequency(f) | Percentage (%) |
|--|--------------|----------------|
| Journal of Turkish Science Education (TUSED) | 5 | 14.8 |
| International Journal of Education in Mathematics, Science and Technology (IJEMST) | 3 | 8.9 |
| Educational Sciences: Theory & Practice | 3 | 8.9 |
| Eurasian Journal of Educational Research | 2 | 5.9 |
| International Journal of Human Sciences | 2 | 5.9 |
| International Journal of Technology and Design Education | 2 | 5.9 |
| Research Based Activity Journal (RBAJ) | 1 | 2.9 |
| Boğaziçi University Journal of Education | 1 | 2.9 |
| Education and Science | 1 | 2.9 |
| Journal of Theory and Practice in Education | 1 | 2.9 |
| El-Cezeri Journal of Science and Engineering | 1 | 2.9 |

| | | |
|--|----|-----|
| Eurasia Journal of Mathematics, Science & Technology Education | 1 | 2.9 |
| Gazi University Journal of Gazi Educational Faculty | 1 | 2.9 |
| Gist Education and Learning Research Journal | 1 | 2.9 |
| International Online Journal of Educational Sciences | 1 | 2.9 |
| International Journal of Social Science(JASSS) | 1 | 2.9 |
| Journal of Education in Science, Environment and Health | 1 | 2.9 |
| Journal of STEM Education | 1 | 2.9 |
| Journal of Educational and Instructional Studies in The World | 1 | 2.9 |
| Primary Science | 1 | 2.9 |
| Procedia Social and Behavioral Sciences | 1 | 2.9 |
| Trakya University Journal of Education Faculty | 1 | 2.9 |
| Turkish Journal of Education | 1 | 2.9 |
| Total | 34 | 100 |

Table 4 shows that that 5 (14.8%) STEM-focused educational studies were published in Journal of Turkish Science Education (TUSED), 3 (8.9%) in each of the International Journal of Education in Mathematics, Science and Technology and Educational Sciences: Theory & Practice, 2(5.9%) in each of International Journal of Human Sciences, Eurasian Journal of Educational Research and International Journal of Technology and Design Education and one (2.9%) in each of the remaining journals.

Topics of Studies

The distribution of study topics in the STEM-focused educational articles are given in Table 5. Besides 4 disciplines in STEM, study titles with keywords such as interest and attitude, tendency, evaluation, opinion and social sciences were also included in the topic distribution.

Table 5. Distribution of Topics in Studies

| Topic Distributions | Frequency (f) | Percentage (%) |
|------------------------------|---------------|----------------|
| STEM Evaluation | 8 | 23.5 |
| Engineering | 6 | 17.6 |
| Science | 5 | 14.8 |
| STEM Opinion | 4 | 11.8 |
| STEM Tendency | 4 | 11.7 |
| Mathematics | 2 | 5.9 |
| STEM-focused Social Sciences | 2 | 5.9 |
| STEM Interest and Attitude | 2 | 5.9 |
| Technology | 1 | 2.9 |
| Total | 34 | 100 |

Table 5 shows that STEM evaluations were carried out in 8 publications (23.5%), and STEM studies related to engineering were present in 6 publications (17.6%). Science-oriented studies were in 5 publications (14.8%); STEM tendency and opinion was found in 4 publications (11.7%); mathematics, social sciences-oriented studies, and interest/attitude studies were in 2 publications each (5.9%). Finally, one publication (3.4%) had technology-oriented STEM studies.

Methodology of Studies

Distribution was done by examining the methodologies used in the identified articles in terms of research method, data collection tool, sample type and data analysis concepts.

a) Research Method

Research methods used in the identified articles are given in Table 6. These methods were identified as quantitative research, qualitative research and mixed research.

Table 6. *Distribution of Research Method Used in the Studies*

| Method of the Article | Frequency (f) | Percentage (%) |
|-----------------------|---------------|----------------|
| Quantitative | 11 | 32.3 |
| Qualitative | 20 | 58.9 |
| Mixed | 3 | 8.8 |
| Total | 34 | 100 |

Table 6 shows that while 20 (58.9%) of STEM-focused educational studies conducted in Turkey used the qualitative method, quantitative method was used in 11 studies (32.3%). Mixed method was used in 3 publications (8.8%).

b) Data Collection Tool

Data collection tools used in the study were viewed in the form of survey, achievement test, perception, interest, attitude tests, interview-interview, observation and alternative evaluation. The obtained data are given in Table 7.

Table 7. *Distribution of Data Collection Tools Used in the Studies*

| Data Collection Tool | | Frequency (f) | Percentage (%) |
|---|--------------------|---------------|----------------|
| Survey | Likert | 10 | 23.3 |
| Achievement Test | Multiple Choise | 2 | 4.7 |
| Perception, Interest, Altitude etc. Tests | | 3 | 6.9 |
| Interview | Semi-structured | 4 | 9.3 |
| | Unstructured | 9 | 21 |
| Observation | | 1 | 2.3 |
| Alternative Evaluation | Concept Map | 1 | 2.3 |
| | Document | 1 | 2.3 |
| | Worksheet | 2 | 4.7 |
| | Diaries | 1 | 2.3 |
| | Situation Analysis | 3 | 6.9 |
| | Fenomenography | 2 | 4.7 |
| | Momograraphy | 1 | 2.3 |
| | Field notes | 2 | 4.7 |
| | Case Study | 1 | 2.3 |
| Total | | 43 | 100 |

Table 7 shows that various data collection tools were used in the studies. Likert-type survey in 10 (23.3%), unstructured scale in 9 (21%), and semi-structured scale in 4 (9.3%) and interest/perception/attitude scales in 3 (6.9%).

c) Sample Type and Size

Distribution of the sample type the researchers are working with in their studies is given in Table 8.

Table 8. *Distribution of Sample Type Used in the Studies*

| Sample Type | Frequency (f) | Percentage (%) |
|------------------------|---------------|----------------|
| Undergraduate | 16 | 47.1 |
| Secondary School (5-8) | 9 | 26.5 |
| High School (9-12) | 3 | 8.8 |
| Non-sampling | 3 | 8.8 |
| Primary School (1-4) | 2 | 5.9 |
| Teacher | 1 | 2.9 |
| Total | 34 | 100 |

Table 8 shows that 16 studies (47.1%) had undergraduate students as the sample, 9 studies (26, 6%) involved secondary school students, 3 studies (8.8%) were non-sampling, 2 studies (5.9%) were with primary school students, and 1 study (2.9%) involved teachers.

Table 9. Distribution of Sample Size used in the Studies

| Sample Size | Frequency (f) | Percentage (%) |
|--------------|---------------|----------------|
| 0-10 | 3 | 8.8 |
| 11-30 | 8 | 23.5 |
| 31-60 | 7 | 20.6 |
| 61-100 | 3 | 8.8 |
| 101-500 | 6 | 17.7 |
| >500 | 4 | 11.8 |
| Non-Sampling | 3 | 8.8 |
| Total | 34 | 100 |

Table 9 shows that 8 studies (23.5%) were conducted with 11–30 participants, and 7 researches (20. 6%) involved 31–60 participants; 6 studies (17.7 %) had 101–500 participants, and 4 studies (11.8%) had a large sample of 500. Furthermore, 3 studies (8.8%) were conducted with a range of 0-10 and 61-100 samples. Finally, 3 studies (8.8%) did not involve samples as they used the situation analysis approach.

d) Data Analysis

Data analyzes used in the researches were examined under two main headings as quantitative and qualitative data analysis. Quantitative data analyses were presented into two subheadings descriptively and predictably in Table 10.

Table 10. Distributions of Data Analysis Used in the Studies

| Data Analysis | | | Frequency (f) | Percentage (%) | | | | |
|--------------------------|------|-------------|--------------------------------|----------------|-------------|----------------------|----|------|
| Quantitative Analysis | Data | Descriptive | Frequency/Percentage Tables | 17 | 23.6 | | | |
| | | | Mean/Standard Deviation | 8 | 11.1 | | | |
| | | | Graphical Demonstration | 3 | 4.2 | | | |
| | | Predictive | t-test | 6 | 8.3 | | | |
| | | | ANOVA/ANCOVA | 3 | 4.2 | | | |
| | | | Factor Analysis | 2 | 2.8 | | | |
| | | | Correlation | 1 | 1.4 | | | |
| | | | Non-Parametric Tests | 3 | 4.2 | | | |
| | | | Qualitative Analysis | Data | Qualitative | Content Analysis | 10 | 13.9 |
| | | | | | | Descriptive Analysis | 13 | 18 |
| Total | | | 72 | 100 | | | | |

Table 10 shows that 17 (23.6%) frequency and percentage tables were given in the quantitative data analyses used in the studies. There are also 8 studies (11.1%) in which the mean/standard deviation data have been tabulated. In the qualitative data analysis, 13 (18%) descriptive analysis and 10 (13.9%) content analysis were included. It was determined that t-test as a quantitative data analysis methods was used 6 times (8.3%). While parametric tests for the quantitative data analysis were used 12 times (16.6%) in the studies, non-parametric tests were used 3 times (4.2%). It was determined that Mann–Whitney U Test and Wilcoxon–Signed Rank Test were used from non-parametric tests. Qualitative data analysis was used 29 times (40.3%) in the examined articles.

DISCUSSION and CONCLUSION

A total of 34 articles on STEM-focused educational studies conducted in Turkey between 2014 and 2016 were examined in this study. There is an increase in the number of articles identified by year: 8 articles were published in 2014 and 2015, and 18 articles were published in 2016. Despite a rapid increase in the number of articles in 2016, the actual number is quite low compared to the numbers in the United States, Europe, and the Far East. Akgunduz (2016) reports a decline in the number of students enrolling in STEM disciplines in universities. This present study reveals that there is a shift from STEM disciplines to healthcare areas, indicating that the interest in the STEM disciplines in our country is low and this interest needs to be increased. Akgündüz and Ertepinar (2015) state in the STEM Education Report in Turkey that a numerous studies were conducted in the United States on STEM fields, only few similar studies were conducted in Turkey. They also emphasized the importance of increasing the number of STEM studies conducted in Turkey. There are two STEM-focused theses and a report in the relevant literature that was not included in the study, which could be considered as a limitation of the study. One of the notable contributions of this study to the related literature is that it indicates a need to give importance to STEM-focused articles, theses, reports, and reviews. Of the articles examined in the study, 79.4% were written in English, and 20.5% were written in Turkish. Moreover, it was determined that the vast majority of the studies (85.2%) examined within the scope of the present study had one, two, or three authors. It can be assumed that this situation was caused by the integration of the four disciplines in STEM studies. Furthermore, the quality of the article increases with the number authors since the manuscript would be reviewed and evaluated by various individuals throughout the writing process (Al, 2005). This situation seems to be encompassed in the articles examined in the scope of the research.

It was determined that the majority of the authors are in developed or rapidly developing institutions such as MoE, Gazi, Sinop, Marmara, and METU. In addition, the majority of the journals in which research articles were published were international peer-reviewed journals (79%), and the remaining were national peer-reviewed journals (21%). The most publications were in TUSED, IJEMST, and Educational Sciences: Theory & Practice.

When the study topics of the articles were examined, it was seen that 41.2% articles are based on STEM disciplines. Rest of the articles (58.8%) were conducted on other subjects. STEM-focused studies are a holistic structure involving the joint study of four disciplines. More STEM disciplines are required at the center of the study topics of the articles examined in this study. In particular, the need for experimental studies continues to increase in the recent years in which the theoretical background of STEM education, which should be perceived as holistic, has begun to emerge (Corlu, 2014; Ferrini-Mundy, 2013). In this context, it is necessary to prioritize practical studies that include STEM disciplines in line with the findings and recommendations both in this study and in the relevant literature.

The majority of the methods (58.9%) used in the examined articles was qualitative. Data collection tools such as interviews, observations, worksheets, situation analysis, and filed notes were most frequently used in the qualitative studies. It was observed that the number of studies carried out in qualitative methodology in educational studies in Turkey gradually increased. For instance, Saban et al. (2010) reveal that the number of qualitative studies in educational science increased from 2002 to 2007. The increase in qualitative researches in the field of science education in Turkey has also inherently influenced the STEM-focused education field. This finding is in line with other studies in the relevant literature. When the qualitative studies examined in this study alone are considered, the

finding that content analysis and descriptive analysis methods are employed the most is parallel to that of previous studies (Güven, 2014). It is suggested to include also quantitative methods in STEM-focused studies in line with the results obtained in the study (Bozkurt Altan & Ercan, 2016; Cinar et al., 2016; Ercan et al., 2016).

The most studied sample type in the articles examined is candidate teachers who are studying undergraduate (47.1%). Other samples are students in secondary school (26.5%), high school (8.8%), primary school (5.9%) and teachers (2.9%). This finding indicates that early childhood period was not used as a sample group in STEM-focused studies in Turkey and teachers were rarely selected as a study group. Soylu (2016) reports that STEM-focused education in early childhood did not yet grasp the importance, despite the fact that many researchers proved STEM to be playing a key role in children's scientific skills and their approaches to the science. This explains the reason for the niche of early childhood period in the study.

Sample sizes in the articles were observed as 8 studies (23.5%) with 11–30 participants, followed by 7 studies (20.6) with 31–60 participants. Furthermore, 6 studies (17.7%) had a range of 101–500 participants. While 4 researches (11.8%) were studied with a large sample of 500 participants, 3 studies (8.8%) have a sample size of 0–10 and 61–100. It can be concluded that small samples were preferred mainly by researchers in STEM-focused educational studies. This result is consistent with the findings of Sozbilir, Kutu, and Yaşar (2013). The finding that the number of samples is usually in this range corroborates the finding that the vast majority of the articles use qualitative research patterns.

It is observed that the frequency and percentage tables are most frequently used in the studies examined in the present study. This is parallel to many qualitative research patterns in the study. Furthermore, it was observed that 13 descriptive analyses (18%) and 10 content analyses (13.9%) were most frequently used in the examined articles. Parametric tests such as t-test, analysis of variance/covariance, and multivariate analysis of variance were used less than the other analyses in the examined articles. The use of quantitative data patterns and, in particular, lesser empirical methods in studies has also affected the rate of using this analysis method.

Given all findings of this study, it is considered that emphasizing the importance of focusing on mixed studies in which quantitative data are supported by qualitative data or experimental research which is little used in the field would increase the quality of STEM studies that are carried out by the STEM-focused education researchers in the future. Nevertheless, the main limitations of the investigated articles are that most studies focused on science and mathematics rather than technology and engineering fields. Studies that involve all 4 disciplines in the STEM field ought to be prioritized. This study would help STEM educators and new researchers, in particular, in their own studies, tracking trends of studies conducted in our country, making appropriate decisions about the study process and reporting their researches.

Acknowledgement

This study was presented at the The IX International Congress of Educational Research 2017 as an oral presentation.

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