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THE INTEGRATION OF HISTORY, TECHNOLOGY, ENGINEERING, ART, AND SCIENCE INTO TRIGONOMETRY OF SENIOR HIGH/VOCATIONAL MIDDLE SCHOOL

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Abstract

The 2013 curriculum contains the accomplishment of learning mindset: student-oriented learning that is active, interactive, networking learning pattern, team-based, using multimedia, corresponding to the characteristics of students, multidisciplinary, and critical. Such the mindset is implemented to the learning process corresponding to the standard process in order to achieve the objective of learning. The 2013 curriculum also presupposes a challenging, joyful and meaningful mathematic learning through problem solving, retrieving, contextual learning, and etc. trigonometry is a unique and applicative topic. Trigonometric application is used particularly in astronomy and geography, and generally it is studied in a variety of areas including geometry, physics, optics, electricity, cartography, maritime, and architecture. The uniqueness and benefit of trigonometric application makes it interesting and important to study. However, the fact in the field and the findings of some research shows that trigonometry is still a difficult and less preferred material to the students. For that reason, there should be innovation in learning to make the trigonometry learnable joyfully, challengingly and meaningfully to the students. Some ways to do so, among others, are to integrate trigonometric learning into historical approach, to use interactive multimedia technology, to bring it into contextual problem related to civil engineering and architectural disciplines, to introduce it into history, technology, engineering, and science. This article was the result of library research raising the theme of the Integration of history, technology, engineering, art, and science, into trigonometry of Senior High/Vocational Middle Schools to realize a joyful and meaningful learning. Through such the innovative ideas, trigonometry is expected to be the most waited for subject to the student.

Key words: trigonometric history, technology, engineering, art, science.

INTRODUCTION

Recognizing and conceiving the advantage of learning trigonometric function, among others, aim to build curiosity so that the students have strong will to explore this material more deeply. The fact in the field shows that many students with difficulty of learning trigonometry even are not interested in learning it because they do not know its advantage in real life. NCTM (2009: 6) revealed that many students experience difficult that they find math as a less meaningful subject. Through the integration of history, technology, engineering, art, and science into trigonometry, the students are expected to be interested in and experience the meaningful

learning process

Trigonometry has been applied widely in daily life, for example in civil engineering and astronomic areas. Trigonometry, the primary measurement instrument in triangle metric science, is very helpful to astronomy and building construction. The fact in real world shows that the distance of an object to other object can be modeled into triangle. Such the simple is developed continuously, integrated into other disciplines to solve the real problem in various areas. Originally, the history of trigonometry was born as the solution to the problem of simple flat structure measure. As the time progresses, trigonometry is also used in other disciplines such as navigation, survey, astronomy, physics, chemistry, medicine, and etc. Such the application is based on the compatibility of sinusoidal function to natural events (phenomena) so that it can be used to predict the probability of a natural phenomenon recurrence; thus human being can determine preventive measures or solutions to such the natural phenomenon.

The integration of history, technology, engineering, art, and science into trigonometry should take into account the basic competency of trigonometry the students will learn, and the basic competence of engineering or natural science to be integrated. Basic competency of trigonometry for Senior High School (SMA) and Vocational Middle School (SMK) in the 2013 curriculum is included into Permendikbud RI (the Republic of Indonesia's Culture and Education Minister Regulation) no.70 of 2013 in the table below.

Table 1 Basic Competency of Trigonometry for SMA/K in the 2013 curriculum

10th Grade	**Basic Competency**
KD. 3.14	Describing trigonometric ratio concept in right triangle through investigating and discussing the relation of ratio of coherent sides in several congruent right triangles.
KD. 3.15	Finding characteristics and relation of trigonometric ratio in right triangle
KD. 3.16	Describing and determining the relation of trigonometric ratio in angle of every quadrant, selecting and applying them to real and mathematic problem solving.
KD. 3.17	Describing trigonometric function concept and analyzing its functional graph and determining the relationship of trigonometric function values of special angles.
KD. 4.14	Applying trigonometric ratio to problem solving
KD. 4.15	Displaying trigonometric function graph
Eleventh Grade	Basic Competency
KD. 3.11	Describing and analyzing sinus and cosines rules and applying them to determining triangle area width.
KD. 4.8	Designing and posing the real problems related to triangle width and applying sinus and cosines rules to solve them.

The 2013 curriculum imposes heavy mandate, emphasizing on principle and standard trigonometric learning in learning based on conception. The standard trigonometric learning process in the 2013 curriculum is included into Permendikbud RI (the Republic of Indonesia's Culture and Education Minister Regulation) no.65. The standard process runs in line with the

one recommended by NCTM (2000) containing: problem solving, reasoning and authentication, skill of integrating or connecting concept, communication and representation. The foundation or essence of such the standard process is the presence of "reasoning" and sense making". Kilpatrick, Swafford, & Findell (2001: 123) stated that without adequate conceptual conception on prerequisite material, the students will have many difficulties in learning subsequent materials. Such the difficulties occur because the learning is less meaningful to students. The learning that only emphasizes on procedural skill will be forgettable and less meaningful to students.

NCTM (2009:6) suggested that recently many students have difficulties because they find math learning as less meaningful. For that reason, it is very important for the teacher to conceive the foundation of standard learning process. Reasoning and sense making are the foundation for organizing a meaningful learning to the students. Meanwhile, the objective of trigonometric learning in Senior High School or Vocational Middle School is to prepare the students to apply trigonometry to real life, real world, science and technology. To achieve the objective, the learning should be meaningful to the students. The meaningful learning will not be forgettable to students and can be the capital to build subsequent concept or to deal with problem in real world. Thus, the learning should refer to standard process, by emphasizing on reasoning and sense-making. The existence of very applicative trigonometry becomes an opportunity of organizing an integrated learning particularly in SMK (Vocational Middle School). In addition to saving time and cost, the learning becomes more meaningful to the students because it is solution- and real problem-oriented. The learning also becomes joyful because it is consistent with the interest and knowledge of students in either Senior High School (SMA) or Vocational Middle School (SMK).

The integration of trigonometric history can be done by including it into introduction section of trigonometric concept, so that the students will understand the history of trigonometry inception. The chronology of idea to integrate trigonometry into functional study can also be inserted here; thereby the students will understand the content they learn mathematically. The students will learn to conceive the difference of domain in trigonometric study, geometrically or analytically.

The integration of technology can be made in introduction to trigonometry as cognitive tools helping the students build trigonometry concept. The integration of history into trigonometric application serves as information source and interactive multimedia stimulating various potentials of students from learning style aspect. The integration of information technology into the process of reporting and presenting the project result will sharpen the students' skills of delivering information, communicating interactively either orally or in written form.

The application of trigonometry into engineering area is very varied, one of which is the one in civil engineering and architecture. Trigonometric subject is very likely to be integrated into civil engineering and architecture subjects, in application or project assessment sections. For example, when the students will conduct survey and mapping on highway, the activity is conducted as engineering subject, and also the application of trigonometric project.

The application of trigonometry to art can be done in project assessment or during exploring the advantage of trigonometric learning. Functional chart painting art in conceiving the natural phenomenon related to trigonometry will be very attractive and meaningful to the students. The art of constructing structure (building) with precise size and artistic appearance will be very challenging to the students of civil engineering or architecture. Productive subject

job in the form of construction design can be equipped with mathematic explanation and logical reason related to sanitation, environmental health, constructing procedure, and etc, and can be used as mathematic project integrated into productive subject job.

The integration of trigonometry into science can be done in introduction and trigonometric application learning process sections. In introduction section, the introduction and exploration of trigonometric benefit in science will be very attractive to the students of Senior High School (SMA) or Vocational Middle School (SMK). Most natural phenomena occurring create a sinusoidal function, the one composed of sinus and cosines function- basic patterns or the combination of them. Sinusoidal is a periodical function, the pattern recurring in constant interval. Many natural phenomena are consistent with sinusoidal pattern. In physical, chemical, biological, and medicinal studies and even music world can utilize sinusoidal function to predict or to study natural phenomena like: water wave, sound wave, tone rhythm (music rhythm), pendulum motor vibration, heart beat, air temperature, cancer cell proliferation, and etc. Charts of cosines and tangent (combination of sinus and cosines) illustrated in the following figure is consistent with musical note (creating music rhythm), so that subsequent rhythm can be recognized in order to yield harmonious tone.

DISCUSSION

The integration of history, technology, and engineering, art, and science into trigonometry can be conducted in many ways. All of them need persistence and patience. The activity can focus on math learning by adding historical, engineering, scientific contents and then used technology to facilitate learning process. The weakness or the constraint encountered lies in time management. Innovative learning often takes much time. This condition requires the teacher to estimate and to schedule smartly thereby the students can master all of competencies. The 2013 curriculum presents many kinds of learning with dense content for each subject (course); for that reason, the students and the teachers have more heave burden. If each subject integrates other material contents taking much time, the students' and the teachers' learning burdens are of course getting heavier. There should be a strategy to keep creating an innovative, joyful, and meaningful learning without the need for increasing learning burden to the students.

One of strategies to keep creating an innovative, joyful, and meaningful learning without the need for increasing learning burden to the students is to collaborate with several subjects in the topics that can be integrated. For example, math is discussing trigonometry, namely determining the triangle width using trigonometric formula; it can be integrated with architectural and construction engineering, namely determining the land width. The students are facilitated in math subject hour to explore and retrieve the formulas they have ever studied and relevant trigonometric formula to define the triangle width. Next, the students are given math project constituting the one from engineering (survey/geomatic) teacher to define a land's width. The implementation of project was conducted in engineering subject hour, then mathematical reporting is assessed by the math teacher, and the engineering one is assessed by engineering teacher. Another example of integration can be conducted in machinery engineering class, in which the students analyze Feris Whell's construction of giant merry-go-round and in trigonometric class the students learn to model the passenger's height matter. Then, they get project to analyze mathematically and technically related to the passengers' safety and comfort, construction toys, engine capacity and capability to play Feris Whell. Similarly, physics and chemistry can be integrated as long as the theme matches the material. However, this implementation of strategy is not easy. Several teachers who will collaborate with should have

shared conception and insight into integrated curriculum, so the problem of implementation will not result. Communicating the collaboration to the curriculum division should also be conducted to prevent the institutional procedure error from occurring.

CONCLUSION AND SUGGESTION

The integrated curriculum is the solution to the problem of incompatibility between the content of 2013 curriculum and the time allocation required to complete the material content in the 2013 curriculum. However, there should be an in-depth study and research to formulate the integrated curriculum that can design collaboration of several subjects into an activity aiming to solve a real problem. For that reason, the teacher should deal with the transition of curriculum change creatively, innovatively, persistently, and patiently.

The easy solution to being innovative in trigonometric learning is to use a good technology, either interactive multimedia or cognitive tool containing the integration of engineering, science, art, and trigonometric history information aiming to solve the real problem in life. Another alternative is to cooperate with peer or between the MGMPs (Subject Teacher Discussion) of school to discuss and to formulate the collaboration between subjects. The learning of discipline content should be carried out at least in its own learning hour, but the project should be design and implemented concurrently.

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