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Development of the PTEAM (Physics, Technology, Engineering, Art, Mathematics) Approach by applying the SOLO Taxonomy

Vivi Mardian*[1], Didi Teguh Chandra[2]
[1,2] Physics Education Department, Physics Department, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia
Jl Dr. Setiabudi No. 229, Bandung 40154, West Java, Indonesia, +62-22-2001108, fpmipa@upi.edu

Corresponding author
[1]vivimardian1111@gmail.com , [2]didichandra@gmail.com

Abstract: Advances in science and technology cannot be separated from developments in physics. Physics discusses all natural phenomena both abstract and real. One of the right learning approaches to master literacy and numeracy skills is PTEAM. PTEAM stands for Physics, Technology, Engineering, Art and Mathematics. PTEAM can be implemented with the SOLO taxonomy. SOLO stands for Structure of the Observed Learning Outcome. There are five levels in the SOLO taxonomy namely SOLO 1 (pre-structural level), SOLO 2 (uni-structural level), SOLO 3 (multi-structural level), SOLO 4 (relational level), and SOLO 5 (extended abstract level). The PTEAM approach is a form of real implementation of the independent curriculum. PTEAM's main goal is to improve students' literacy and numeracy skills by applying engineering and technology themes to build the Unitary State of the Republic of Indonesia. PTEAM's learning innovations involve parents, teachers and the community.

Keywords: PTEAM, SOLO Taxonomy, Approach.

Introduction

Advances in science and technology cannot be separated from developments in physics. Physics discusses all natural phenomena both abstract and real. Observable phenomena such as motion of objects, sound waves, fluids, Newton's laws and so on. Meanwhile, abstract phenomena can be in the form of electric fields, magnetic fields, photons, electrons, celestial bodies outside the solar system and so on. The discovery of new materials is the basis for the industry to create gadgets that are lightweight but multi-functional. Therefore, the development of physics will have a positive impact on society.

So far, learning physics is often considered difficult by students. Physics is an abstract subject and is not a favorite for students, especially students who do not understand mathematics. This is an essential problem for teachers and the government. If this problem continues, the number of enthusiasts in physics will continue to decrease, both in universities and in the world of work. As we know, students who understand physics concepts have a great opportunity to choose their favorite majors such as nuclear energy, civil engineering, electrical engineering, astronomy, mathematics, geophysics. Students' difficulties in learning physics may be due to not being trained with the 21st century skills that are needed in this era.

21st century skills are often associated with skills in the industrial revolution 4.0 era. The 21st century skills include higher order thinking skills, critical thinking skills, creative thinking skills, communication skills, collaboration skills, data literacy skills, numeracy skills, technology literacy skills, STEM literacy skills, problem solving skills, decision making skills. Among these skills, the Indonesian government through IKM (Merdeka Curriculum Implementation) prioritizes literacy and numeracy skills.

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According to UNESCO, literacy is a set of real skills, especially in reading and writing regardless of context, acquired by whom and from whom. Another opinion from the EDC (education development center) states that literacy is more than just the ability to read and write. Literacy is an individual's ability to use the potential and abilities they have in their lives, in other words as the ability to read words and read the world. The National Institute for Literacy conveys that literacy is an individual's ability to read, write, speak, count, and solve problems at the required level of expertise, in the family, work, and society. Therefore, literacy skills are important for students to achieve success during learning and in the future.

Numerical skills are no less important in the era of the industrial revolution 4.0. According to Cockroff in Goss (2011) numeracy is a student's ability to use numbers to solve problems in everyday life practically. Numeracy skills are skills and knowledge in (1) using various kinds of numbers and symbols related to basic mathematics to solve practical problems in various kinds of contexts of everyday life, (2) analyzing information displayed in forms (graphs, tables, charts , and so on, (3) interpreting this information to predict and make decisions (OECD in Ayuningtyas & Sukriyah, 2020).So, numeracy skills are not only limited to understanding mathematical concepts but also skills in further analyzing these numbers.

One of the right learning approaches to master literacy and numeracy skills is PTEAM. PTEAM stands for Physics, Technology, Engineering, Art and Mathematics. PTEAM is a more specific derivative of the STEM approach. PTEM is an approach to learning physics that is directly related to technology, engineering, art and mathematics. With the PTEAM approach students are expected to be able to master 21st century skills, especially literacy and numeracy. PTEAM includes scientific literacy skills, technological literacy, engineering literacy, and numeracy literacy. PTEAM makes learning more meaningful because students are taught to think creatively, read environmental conditions and design creative solutions to problems found in real life. To implement PTEAM, an appropriate taxonomy is needed to be able to assess every learning process that students go through.

PTEAM can be implemented with the SOLO taxonomy. SOLO stands for Structure of the Observed Learning Outcome. The SOLO taxonomy was born based on the study of academic teaching results (Brarand & Dahl, 2009). There are five levels in the SOLO taxonomy namely SOLO 1 (pre-structural level), SOLO 2 (uni-structural level), SOLO 3 (multi-structural level), SOLO 4 (relational level), and SOLO 5 (extended abstract level). At the first level, students are considered not to have any understanding but maybe students already know some of the scattered pieces of information. Furthermore, at the uni-structural level students are able to explain a simple term. Then, at the multi-structural level students can solve problems, read graphs, and apply concepts well. At the next level (relational) students are able to analyze more deeply the causes and effects of an incident. Finally, at the highest level (extended abstract), students can formulate hypotheses, transfer knowledge to others, and criticize scientifically.

The SOLO taxonomy is one of the taxonomies recommended by the Indonesian government through the Minister of Education. This is because the SOLO taxonomy makes it easy for teachers to design learning in a structured way starting from pre-learning, learning process, and post-learning. Each SOLO level will contain cognitive, psychomotor and affective dimensions. The SOLO taxonomy is expected to be integrated with the PTEAM approach. That way, teachers should really understand the concept of the SOLO taxonomy, especially in learning physics.

In the independent curriculum, there are seven P5 themes (projects to strengthen Pancasila student profiles) developed by the Ministry of Education and Culture. These themes include a sustainable lifestyle, local wisdom, Bhinneka Tunggal Ika, Build Your Body and Spirit, Voice of Democracy and Engineering and Technology to Build the Unitary State of the Republic of Indonesia. PTEAM's approach will lead to the 7th theme, namely engineering and technology to build the Unitary State of the Republic of Indonesia. This paper will discuss the concept of the PTEAM

approach and the role of teachers and parents in realizing PTEAM.

Results and Discussion

Discussion

1. The concept of PTEAM approach

The PTEAM approach aims to integrate real physics concepts by combining other fields, namely technology, engineering, and mathematics so that students master 21st century skills. The 21st century skills in question are literacy, numeracy, and problem-solving skills. Some of the reasons for implementing the PTEAM approach in learning are:

a. Teachers are obliged to train students to become a superior generation and sensitive to environmental issues
b. Teachers are responsible for preparing students to face challenges in the 5.0 industrial revolution era
c. Students need more meaningful learning
d. Teachers and students both learn to master other fields of science to solve various problems.

PTEAM implementation is aided by the SOLO taxonomy hierarchy. In general, each level of the SOLO taxonomy will describe the activities carried out by teachers, students and parents. So that in learning not only the teacher is involved but parents should also take a role for student success. At the pre-structural level students will obtain information from the family environment. At the uni-structural, multi-structural, relational level, students will get the right concepts and procedures from the teacher. Finally, at the extended abstract level, students will learn independently from the surrounding environment in accordance with the application of physics.

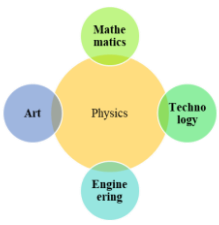

Figure 1. PTEAM integration

Contoh desain RPP dengan pendekatan PTEAM

Jenjang sekolah : SMA
Kelas : XII
Mata Pelajaran : Fisika
Materi : Listrik Dinamis
JP : 5 JP
Model Pembelajaran : PJBL dan Discovery
Metode Pembelajaran : Diskusi, Demonstrasi, Eksperimen, Projek
Sumber belajar : Buku, Internet, Workshop

Level SOLO	Pertemuan ke-	Lokasi	Aktivitas Siswa	Perangkat pendukung
Pre-struktural	1	Di rumah	Siswa memperoleh ilmu dan pengetahuan awal dari keluarga (ibu, ayah, kakak)	Family E-Learning
Uni-struktural	1	Di sekolah (Lab Fisika)	Siswa memperdalam konsep dan prosedur listrik dinamis dengan guru	E-learning, simulasi, internet, laboratorium
Multi-struktural	1, 2	Di sekolah (Lab Fisika)	Siswa menggunakan konsep untuk menyelesaikan bentuk soal LOTS dan HOTS	E-learning, simulasi, internet, laboratorium
Relasional	3,4	Di sekolah (Lab Fisika)	Siswa melakukan percobaan terkait listrik dinamis	E-learning, simulasi, internet, laboratorium
Extended abstract	5	Di lapangan	Siswa memperoleh pengetahuan baru dari pihak PLN atau dari laboran teknik elektro di perguruan tinggi	E-learning, E-LKPD, laboratorium

Figure 2. An example of an RPP design with the PTEAM approach

Figure 3. Discovery learning model syntax

Langkah-langkah pembelajaran

Sintaks / level SOLO	*Kegiatan siswa*	*Kegiatan guru*	*Kegiatan orang tua*
Stimulation/pre-struktural	Membaca sekilas materi listrik dinamis Menulis permasalahan tersebut dikertas dan membawanya ke kelas	Membuka pembelajaran Menampilkan fenomena listrik dinamis dalam bentuk video Menanyakan kepada siswa masalah yang ditemukan di rumah terkait listrik dinamis	Menemukan masalah misalnya: lampu di kamar mandi dan dapur mati tiba-tiba. Menjelaskan masalah tersebut ke anak
Problem statement/uni-struktural	Menyampaikan rincian masalah yang ditemukan di rumah	Menuliskan daftar masalah yang ditemukan siswa	
Data collection/ multi-struktural	Mengumpulkan informasi dari sumber Melakukan percobaan	Membimbing siswa menemukan informasi dan melakukan percobaan	
Data processing/multi-struktural	Mengolah data berkelompok	Memimbing siswa melakukan pengolahan data	
Verification/relasional	Menganalisis hubungan variable dari percobaan Mempresentasikan hasil percobaan	Mengamati dan memfasilitasi siswa Memberikan masukan dari hasil percobaan	
Generalization/ relational	Menarik kesimpulan Kedua lampu di kamar mandi dan dapur mati sekaligus karena kedua lampu disambungkan secara seri. Jadi, karena bola lampu dapur rusak sehingga lampu di kamar mandi juga tidak hidup. Menyampaikan sebab akibat dari permasalahan kepada orang tua	Membimbing siswa menarik kesimpulan	Memberikan tanggapan terhadap hasil belajar anak

Figure 4. Learning steps

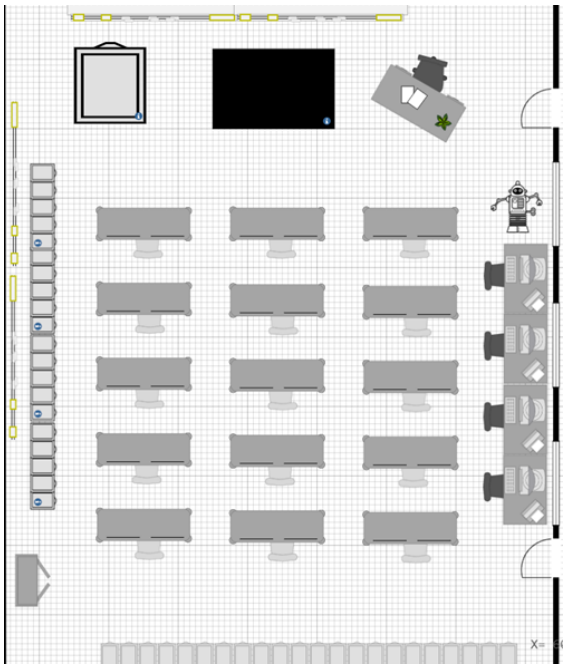

Figure 5. Class design

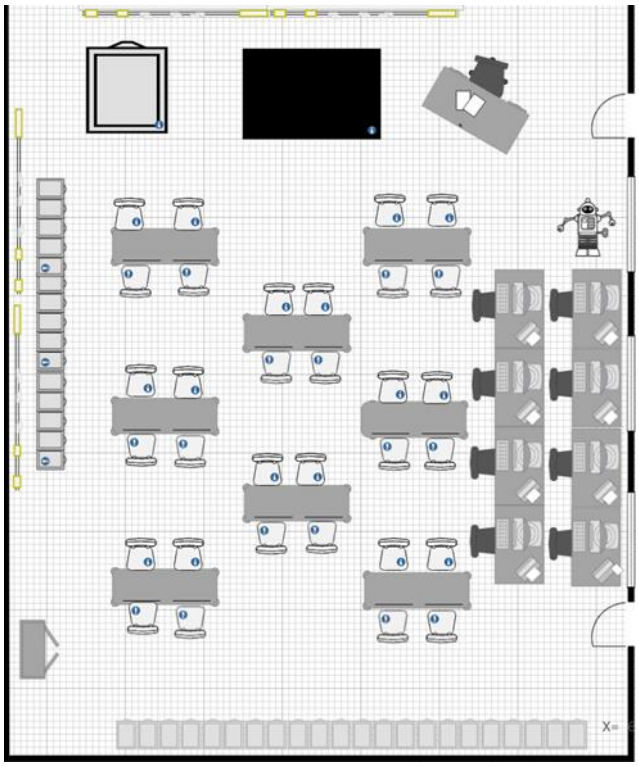

Figure 6. Lab design

Figure 5 shows the class design for ordinary learning. In one class there are 15-20 students, one teacher and one robot. The robot is in charge of helping teachers and students during the learning process. For example, when the teacher applies the discovery learning model, students will conduct more discussions, use computers, and conduct experiments. Robots that have been arranged in such a way will be able to help students when students find difficulties. The PTEAM approach does not only focus on projects but also prioritizes student character development. The lab is also equipped with lockers and physics experiment tools. When students carry out discussions or experiments, the lab will look like Figure 6. Students are limited to one group consisting of only 4 students. The lab also allows teachers to invite resource persons to carry out mini workshops if it is not possible to bring students to the field. Therefore, the PTEAM approach prioritizes student success in learning.

2. The Role of Teachers and Parents

Teachers have a very important role in realizing the success of student learning. Teachers are no longer the only source of learning for students. The teacher is only a facilitator for students. That is, the teacher directs students in using various learning resources ranging from printed books and electronic books. In addition, teachers should train literacy and numeracy skills in students. Such learning will involve students actively in learning. Students will be more motivated and aware of the importance of the material.

In fact, in several school physics teachers still do not maximize the use of instructional media. Learning media is important for teachers to make it easier for teachers to explain material concepts. One of the proofs is that teachers very rarely bring students to the physics laboratory and bring teaching aids to class. Many studies have stated that students will be more interested when connected to natural phenomena or events they have experienced. The teacher as much as possible demonstrates props that students can recognize when starting learning.

The PTEAM approach will encourage teachers to be more creative in directing students to think creatively and innovatively. Teachers and students learn to find solutions to any problems students find. In the learning process, students no longer study in class but study in a physics laboratory like a laboratory in a university. This aims to facilitate students in innovating and conducting experiments.

The laboratory does not only contain real experimental tools and materials but also several computers equipped with virtual experiment software such as PhET, Tracker, Pasco, and so on. Thus, PTEAM learning outcomes are not only an increase in knowledge but students also master the skills of technological literacy, scientific literacy, and being scientific.

The difference between the PTEAM approach and other approaches lies at the end of the learning topic meeting. For example, dynamic electricity material will be studied by students in a structured way in the physics laboratory for 4 meetings. Then, the teacher invites students to visit PLN. This aims to introduce students more deeply about dynamic electricity, the application of physics, how electric current works, and the criteria for hydropower to generate hydropower. In wave material, teachers can take students to BMKG and many other agencies that are closely related to physics

material. PTEAM learning assumes that all parties, including families, schools, and communities, mutually support the success of student learning.

Parents are the child's first teacher in the family environment before taking formal education at school. Maybe in the past parents were only obliged to send their children to school. However, in the 21st century, parents also play a supervisory role for their children. At the pre-structural level, parents must be able to help their children remember the learning material that will be studied at school. The question is, what about parents who do not pursue higher education? This is not a problem because every parent has the same access as a teacher to find out about their child's progress at school. So, the teacher will design short questions and answers and post on the parent portal. Parents are only responsible for training their children to remember the material they have learned.

PTEAM's approach also displays other uniqueness, such as parental involvement in their child's education. Some phenomena in the house often occur, for example, the bedroom lights suddenly turn off even though they have just been replaced. Another example, broken glass because hot cooking oil poured. Parents can convey this phenomenon to their children or send a note on the parent portal. Then, at school the teacher will provide scientific explanations to students regarding the phenomena that occur at home. If the phenomenon is related to the topic being studied at that time the teacher can guide students to find causes and solutions to these problems. These problems will not be far from the concepts of physics, technology, engineering, art and mathematics. Therefore, the PTEAM approach will train students to become students who think as problem solvers, creators and innovative.

Conclusions

The PTEAM approach is a form of real implementation of the independent curriculum. PTEAM's main goal is to improve students' literacy and numeracy skills by applying engineering and technology themes to build the Unitary State of the Republic of Indonesia. PTEAM's learning innovations involve parents, teachers and the community.

References

Abdul, Fahri. (2022). Memahami Pengertian Literasi, Tujuan, Jenis, & Contohnya. Ruang Guru. Diakses pada 19 Nomber 2022. Memahami Pengertian Literasi, Tujuan, Jenis & Contohnya (ruangguru.com)

Ayuningtyas, N., & Sukriyah, D. (2020). Analisis pengetahuan numerasi mahasiswa matematika calon guru. Delta-Pi: Jurnal Matematika dan Pendidikan Matematika, 9(2).

Biggs, J. B & Collis, K. F., (1982). Evaluating The Quality of Learning the SOLO Taxonomy (Structure of the Observed Learning Outcome). New York: Academic Press.

Brabrand, C., & Dahl, B. (2009). Using the SOLO taxonomy to analyze competence progression of university science curricula. Higher Education, 58(4), 531-549.

Goos, M., Dole, S., & Geiger, V. (2011). Improving numeracy education in rural schools: A professional development approach. Mathematics Education Research Journal, 23(2), 129-148.