The analysis of student kinesthetic learning activity on the materials of Compton and photoelectric effects

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Abstract. This study aims to analyze the kinesthetic learning activities of students on Compton and photoelectric effects. This further involved a qualitative descriptive study, where students of class XII Mathematical and Natural Science 2, State of Madrasah Aliyah in Palu Region (Central of Sulawesi, Indonesia), were the sample population examined, in the odd semester of 2018/2019 academic session. Data was obtained through observation of learning activities, concept understanding tests, interviews and learning style identification questionnaires. The selection of respondents was based on the level of understanding of students' concept categories. The results of the study showed that students perform kinesthetic learning activities very well, as seen from their endeavors in following the lessons and the results of theoretical understanding assessments, which were observed to be in the high category. Furthermore, the interview evaluated that the students are happy with the kinesthetic learning method carried out as it promoted their understanding and recollection of the content of the material and questionnaires indicate that students have visual, auditory and kinesthetic learning styles. From the performance of Compton and the photoelectric effect, it was shown that students playing as electrodes and electrons (kinesthetic learning style) possess high understanding of the concept in the kinesthetic learning model.

1. Introduction
The learners with different learning styles have different sets of learning sequences [1]. Every student has their personalized pattern of absorbing and processing information received [2], as one with a visual learning style finds it easier to understand from what is seen. Furthermore, a person with auditory cleverness finds it easier to learn from what is heard, however, kinesthetic learning patterns are observed in someone who can easily mentally grasp information from motion and touch [3].

Based on the students’ preferred technique, tutors can further adjust their teaching methods to suit their needs. The optimal learning requires that students receive instruction tailored to their putative learning style [4]. This process however involves the knowledge of the style of students as they must master various instruction formats and further be capable of being experts in the materials provided, motivators and sources of information, instructors and evaluators [5].

Motivation is needed for students to have a better and effective understanding of the material presented, by making learning activities interesting, through the involvement of a kinesthetic approach [6]. Furthermore, this education pattern increases student motivation to take lessons,
decreases boredom and they are better able to understand the material given [7].

Kinesthetic Learning Activities (KLA) is a process that involves more physical actions than passive listening, with the main characteristic, being the active use of physically participating in material presentations in class [8]. KLA supports increased understanding of student concepts, encourages them to learn in new ways, increases their involvement and participation [9], and it is also fun and memorable and they inject a great deal of excitement and enthusiasm into the classroom [10].

In studying physics in class, there are several phenomena that can be seen with the eye. However, there are also many phenomena that cannot be seen with the eye so that students may experience difficulties in learning which lead to a lack of understanding of concepts and can even cause students to experience misconceptions [11,12]. Based on this, of course a teacher must implement learning that can facilitate students in learning so that students' conceptual understanding is good. One way for teachers to overcome these problems is by implementing KLA in learning whose concepts are difficult for students to understand.

Several studies have implemented KLA. The drawback of this research is that it applies KLA to concepts that can be observed by students [13–15]. There are still a few researchers who conduct research on the implementation of kinesthetic learning on material whose concepts cannot be seen by students directly. One of the concepts that cannot be observed by the human eye is Compton and photoelectric effects.

Compton and photoelectric effects are interesting phenomena in modern physics which became the cornerstone of its development and it is also a part of the dualism of particle waves. Furthermore, both phenomena take place in a microscopic order hence they cannot be directly observed. The process of learning physics requires that teachers generally use images or animations, while presenting the materials, however, not all students can understand the explanation, because each student possesses a preferential learning style [16].

In this study, KLA was applied to the Compton effect and the photoelectric effect materials, aimed at improving understanding, where students demonstrated the behavior of microscopic objects, to facilitate learning of the study material.

2. Methods

This is a descriptive qualitative research, which describes students' KLA. The sample in this research is grade 11 students (children with an age range of 18-19 years) majoring in science at a public school in Central Sulawesi, Indonesia, during the odd semester of 2018/2019.

Respondents consisted of 17 students who had never studied Compton and photoelectric effect, where each was presented with different learning styles. Furthermore, the selection of respondents was based on level of understanding the concept and the differences in learning styles, based on the level of understanding of students' concepts will be grouped into three categories, namely high category, medium category and low category. Two respondents will be taken from each category so that a total of 6 respondents will be interviewed and given a learning style questionnaire until the learning style of each respondent is obtained.

The research was conducted by providing material on the working principle of both topics in physics, accompanied by a demonstration (kinesthetic learning activities) and a test was administered. The selected respondents were interviewed and given questionnaires.

The test consisted of 5 items on the principle of the Compton and photoelectric effects and the interviews related to the materials as well as information on the respondent's learning pattern. Furthermore, the questionnaire consisted of 18 items consisting of several statements about student learning styles, with scores determined by the Guttman scale, where each "YES" answer was graded 1 and the "NO" answer was 0 [17].

Determination of student learning styles were as follows:
1) The highest score in a group of learning style statements shows the dominance of the learning style.
2) The two peak values and equivalent records from both groups of learning style statements indicates the dominance of the two learning styles
3. Results and Discussion
The photoelectric effect and the Compton Effect are materials that are difficult for students to understand because they are abstract phenomena that cannot be observed directly, hence students need to use their imagination and utilize learning media.

![Figure 1. Concept: (a) Compton Effect and (b) photoelectric effect.](image)

Figure 1 illustrates two phenomena in physics, where the Compton Effect event shown in Figure 1 (a), shows that photons that move with a certain wavelength hit idle electrons, which bounce hence the photons scatter with a larger wavelength and the difference between the wavelength of the initial and scattered photon is shown in Equation 1.

\[
\lambda' - \lambda = \frac{h}{m_e c} (1 - \cos \cos \theta)
\]  

(1)

Where:
\(\lambda'\) is the initial wavelength,
\(\lambda\) is the scattered wavelength,
\(h\) is the Planck's constant,
\(m_e\) is the idle mass of electrons,
\(c\) is the speed of light, and
\(\theta\) is the photon scattering angle relative to the flat line.

Conversely, the photoelectric effect event, as shown in Figure 1 (b), illustrates a relationship between several physical parameters as shown in Figure 2. where a higher intensity of the photon that hits the metal plate, generates a greater electric current as shown by Figure 2 (a). Furthermore, the electrons on the metal plate are further excited if the photon energy involved is greater than the metals threshold energy as shown in Figure 2 (b).

![Figure 2. Shows (a) the relationship between physical parameters in the photoelectric effect event and the effect of photon intensity on the electric current produced as well as (b) the correlation between the frequency and kinetic energy of electrons.](image)

At the time of the implementation of learning in accordance with the student activity observation sheet there are 5 stages. The first stage is paying attention and listening to explanations about the
learning objectives, noting the learning objectives presented, understanding the problems presented, and students' skills in answering questions. The second stage, in groups according to the results of group division, paying attention to explanations, noting the points of learning that are delivered, asking for explanations that are not yet clear. The third stage, draw the lottery to find out the role played, students actively discuss in their respective groups discussing the role they have got, students prepare to play a direct role as part of the Compton effect and the photoelectric effect, students use the facilities provided. The fourth stage, another group evaluates the group that appears, students focus their attention on the role played and do not do things that are not related to procedures, students make movements according to their role, the next designated groups are ready to appear. The fifth stage, reading out the assessment of the performance of each group, giving conclusions when asked, writing the conclusions that have been concluded, doing a test of understanding the concept of the Compton effect and the photoelectric effect.

Using KLA, students performed two demonstrations, where some roles in exhibiting the Compton Effect, involved photons arrival, idle electrons, scattered photons, and bounced electrons. Conversely, the photoelectric effect exhibition required that students act as photons, metal plates, electrons in metal, and electrodes (both anodes and cathodes).

The results show that students demonstrated both physical phenomena very well, with data obtained through the observation of their activeness, during the course of the lesson, at a participatory percentage of 95%. Furthermore, their KLA was observed based on the roles played, utilizing indicators, with a purpose to find out the suitability of the students' movements, while acting out their characters.

The kinesthetic indicators assessed, include locomotor skills (walking and marching), nonlocomotor skills (turning the body, standing up and reaching out), eyes and foot coordination (ability to manipulate objects), as well as the ability to control and regulate the body (take stars and change direction). Furthermore, students will be given a concept understanding test after kinesthetic learning is applied. Based on data analysis, the average score obtained by students is 69.7 or categorized in the medium category. Category grouping further used the standard deviation [18].

The categorized students, from the results of the calculation of standard deviations as seen in Table 1, were used as the basis for grouping students, where two respondents were selected from each category to be interviewed and further administered a learning style questionnaire to obtain the data in Table 2.

| Table 1. Score of Respondent Category Determination |
|-----------------------------------------------|
| High | Moderate | Low |
| Score | ≥ 78,35 | 78,35 < x < 61,05 | ≤ 61,05 |

In the Compton effect demo, students who acted as photons, energy and colliding electrons were more active in kinesthetic activity because they carried out more physical movements and thus fulfilled all indicators, as shown in Figure 3 (a).

Figure 3. Student kinesthetic activity on Compton effect: (a) The role of students as electrons,
energy and photons; (b) The role of students as silent electrons and x-rays.

However, the opposite occurred when students acted as x-rays and idle electrons, where they tend to be more passive in kinesthetic activities, as shown in Figure 3 (b), because little movements were required. In line with the results obtained at the demonstration of the Compton Effect, it is known that students, who acted as photons and electrons according to the photoelectric material, were more active in kinesthetic activity because they made more physical actions and thus fulfilled all kinesthetic indicators (Figure 4 (a)).

![Figure 4](image)

**Figure 4.** Student kinesthetic activity in the demonstration of the photoelectric effect: (a) The role of students as electrons and photons; (b) The role of students as light sources, anodes and ketodes.

In the photoelectric effect, students who acted as light sources, anodes and cathodes, were more passive in kinesthetic activity, as it is known through the indicators that only made a few movements (Figure 4 (b)).

The results further indicated that the level of understanding of the respondents on the working principle of Compton and photoelectric effects were influenced by the role played as it was observed that those who obtained active roles, e.g. colliding electrons, energy, and photons tend to possess a better understanding and were able to explain the working principles of Compton effects and photoelectric effects. In contrast, respondents who obtained the passive roles, e.g. X-rays, light sources, cathodes, anodes and idle electrons did not have a good understanding of the concept of both phenomena and they also possessed lower explanatory abilities.

The results of the identification of learning styles and categories or levels of students' conceptual understanding after studying by the demonstration of compton and photoelectric effects are shown in Table 2. These respondent were representatives for each category in learning styles. It is known that respondents with kinesthetic learning styles (R-07), obtained high learning outcomes because in the demonstration of both physics phenomena, respondents (R-07) obtained a passive role (as X-rays and light sources) sequentially, where they only focused on their character.

| Respondent | Score | Category | Learning style    |
|------------|-------|----------|-------------------|
| R-07       | 95    | High     | Kinesthetic       |
| R-06       | 80    | High     | Auditory Kinesthetic |
| R-09       | 70    | Moderate | Auditorial       |
| R-04       | 65    | Moderate | Visual           |
| R-15       | 55    | Low      | Auditorial       |
| R-05       | 60    | Low      | Visual           |
It is also known that those who have a kinesthetic learning style (R-06 and R-07) used the graphical potential in their learning activities, hence, when playing their roles, they observed objects, figures and symbols around them, thus, the information was easier to obtain. Table 2 also shows that students with Kinesthetic Learning Styles and its combined resulting better understanding of the concept after implementing KLA than others student. This is in line with the research that has been done which states that students' understanding of concepts will increase if students are interested and demonstrate the material to be studied [19]. This research is also in line with previous research which states that if you want to improve students' understanding skills, it is not enough to learn in a passive style, but it must be kinesthetic (involving the movement of all limbs) [20].

Through role playing in KLA, it is known that students were happy to learn physics. KLA’s can engage other important learning styles, such as Felder and Silverman’s active, sensing, intuitive, visual, or global learners [21]. Furthermore, fun learning attracts students' attention because the various methods applied in the education process are interesting [22].

4. Conclusion
Students participated in excellent kinesthetic learning activities, which led them to be more active and happy, determined by observing their ability to follow the lessons, test results and interviews. The application of KLA, helped the students to understand and remember the material (shown in the learning style questionnaire). In kinesthetic learning, respondents with visual knowledge styles were in the high category because they have an active role hence understanding the working principle of the Compton Effect and the photoelectric effect was enhanced.

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References
[1] Klašnja-Milićević A, Vesin B, Ivanović M and Budimac Z 2011 E-Learning personalization based on hybrid recommendation strategy and learning style identification Comput. Educ. 56 885–99
[2] Prithishkumar I J and Michael S A 2014 Understanding your student: Using the VARK model J. Postgrad. Med. 60
[3] Lista L, Atmowardoyo H and Salija K 2016 The Effects of Visual Auditory Kinesthetic Learning Style as Technique in Improving Students’ Writing Ability ELT Worldw. J. English Lang. Teach. 2 62–76
[4] Pashler H, McDaniel M, Rohrer D and Bjork R 2008 Learning styles concepts and evidence Psychol. Sci. Public Interes. Suppl. 9 105–19
[5] Zapalska A and Brozik D 2006 Learning styles and online education Campus-Wide Inf. Syst. 23 325–35
[6] Grant C and Osanloo A 2014 Understanding, Selecting, and Integrating a Theoretical Framework in Dissertation Research: Creating the Blueprint for Your “House” Adm. Issues J. Educ. Pract. Res. 4 12–26
[7] Suryadin, Merta I W and Kusmiyati 2017 Pengaruh Model Pembelajaran Visual Auditorial Kinestik (VAK) terhadap Motivasi dan Hasil Belajar IPA Biologi Kelas VIII SMP Negeri 3 Gunungsari Tahun Ajaran 2015/2016 J. Pijar MIPA 12 19–24
[8] Gashgari A and Young G 2017 A Study of Kinesthetic Learning Activities in Teaching Computer Algorithms in Saudi Arabia Int’l Conf. Frontiers in Education: CS and CE
[9] Mobley K and Fisher S 2014 Ditching the Desks: Kinesthetic Learning in College Classrooms
Soc. Stud. 105 301–9

[10] Richards A 2019 Teaching Mechanics Using Kinesthetic Learning Activities Phys. Teach. 57 35–38

[11] Saputra O, Setiawan A, Rusdiana D and Muslim 2020 Analysis of students’ misconception using four tier diagnostic test on fluid topics Int. J. Adv. Sci. Technol. 29 1256 – 1266

[12] Saputra O, Setiawan A, Rusdiana D, Muslim and Izzuddin M A 2021 The development of SE-POW (predict-observe-write) learning model assisted by virtual simulation to reduce the quantity of high school students’ misconceptions on fluid topics Journal of Physics: Conference Series vol 1806

[13] Whitworth B A, Chiu J L and Bell R L 2014 Kinesthetic Investigations in the Physics Classroom Phys. Teach. 52 91–93

[14] Ganesh P 2020 Connecting Torque and Friction Using Tactile Learning Activities Phys. Teach. 58 659–66

[15] Richards A 2020 Teaching Electricity and Magnetism Using Kinesthetic Learning Activities Phys. Teach. 58 572–6

[16] Gilakjani A P 2012 A Match or Mismatch Between Learning Styles of the Learners and Teaching Styles of the Teachers Int. J. Mod. Educ. Comput. Sci. 4 51–60

[17] Sugiyono 2015 Quantitative Research Methods, Qualitative, and R & D. (Bandung: Alfabeta)

[18] Sudjana 2005 Statistical Methods (Bandung: Tarsito)

[19] Ozkan G and Selcuk G S 2016 Facilitating conceptual change in students’ understanding of concepts related to pressure Eur. J. Phys. 37 1–20

[20] Leinonen R, Asikainen M A and Hirvonen P E 2013 Overcoming students’ misconceptions concerning thermal physics with the aid of hints and peer interaction during a lecture course Phys. Rev. Spec. Top. - Phys. Educ. Res. 9 1–22

[21] Begel A, Garcia D D and Wolfman S A 2004 Kinesthetic learning in the classroom SIGCSE Bulletin (Association for Computing Machinery, Special Interest Group on Computer Science Education) vol 36

[22] Garneli V, Giannakos M and Chorianopoulos K 2017 Serious games as a malleable learning medium: The effects of narrative, gameplay, and making on students’ performance and attitudes Br. J. Educ. Technol. 48 842–859