
Need Analysis for Research and Development of an Automatic Sprinkling System as Instructional Aids in Physics

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Abstract

Instructional aid are infrequently seen in physics learning activities, even though they are essential for enhancing the learning experience. Therefore, the development of instructional aids is required to facilitate understanding and applying physics concepts more accessible to students. The development of instructional aids should be guided by needs analysis factors such as learning motivation, curriculum analysis and materials learning analysis, student's learning style, student's need, and prevailing learning media. This study used survey method with case studies approach. This study aims to obtain data and analyze the student's needs toward to the instructional aid soil moisture measurement in physics lesson. Samples in study were student of 33 peoples, taken from class XH at SMAN 71 Jakarta with technique purposive sampling. This study resulted: physics learning motivation of student were in the medium category, with attention 87.88%, relevance 55.30%, confidence 60.61% and satisfaction 87.12%. Curriculum analysis show in class X, measurement lesson still can be developed to soil moisture measurement based on contextual learning approach. Regarding learning styles, 48,48% students preferred visual learning, 24.24%, and 27.27% kinesthetic. About 59.85% students experience difficulties in learning physics. Nonetheless, 79.55% of them agreed that hands on method could help reduce these difficulties. As many as 87.12% of students agree that they need automated instrument in physics practice and only 39.39% of students has known about Arduino. The frequently used learning media in class were on audio-visual category, starting from power point slide presentation, Canva's slides presentation, video, simulation and animation. All of those findings were supported research and development of oto-sprinkler system by using humidity sensor and Arduino Uno. Result of this study will become the base contextual in developing contextual teaching aids in form of soil moisture measurement, so that can increase the physics learning motivation in student.

Keywords: Learning physics motivation, Student's need, Learning media, Learning styles, Physics instructional aids, Arduino, Humidity sensor, Preliminary studies

1. Introduction

Results of the Program for International Students Assessment (PISA) and The Trends in International Mathematics and Science Study (TIMSS) shows that student physics learning

achievement in Indonesia was lower than other nation (Khusaini, 2021). In despite of physics is one of science field that supports the progress of developing and implementing technology in civilization life. One of the causes of low achievement in studying physics was the low level of learning physics motivation.

The level of motivation to learn physics at the senior high school (SHS) Surakarta, was 58.86% in attention aspect, 57.08% in relevance, 55.28% in confidence, and 60.14% satisfaction (Sari et al., 2018). In Jambi, the level of motivation to learn physics is shown by only 13.9% of students being in “Good Enough” level (by score 65.1 – 85.0), 60.8% of students were in “Good” level (by score 85.1 – 105) and only 25.3% students in “Very Well” level of physics learning motivation (by score 105.1-125) (Ramadhanti et al., 2022). In the city of Malang, motivation to study physics among 51% high school students were on “Moderate” category (by score 61-80) and only 20% on “High” (by score 81-100) (Etikamurni et al., 2023). The results of these studies show motivation in learning physics was still dominated by “Good” and “Good enough” or “Moderate”, so it needs for improvement act.

The results of moment product correlation analysis showed that motivation to learn physics is positively correlated with understanding of physics concepts (Shidik, 2020). Learning physics motivation were correlated by physics learning outcomes, which has been indicate by the closeness relationship value in the Pearson correlation line of 0.990 (Jusman et al., 2023). Learning motivation is significantly related to scientific literacy abilities in high school students in Makassar City with a correlation coefficient r of 0.307, although in the low category (Jen et al., 2023). This low closeness value still shows that there is a positive correlation between cognitive learning outcomes with learning motivation (Akbar et al., 2023)(Akbar et al., 2023). The important role of motivation to learn physics in the learning process and outcomes encourages efforts to increase motivation to learn physics.

Physics learning motivation in students can pushed through learning contextual and easy understood (Aprilia et al., 2022). Contextual learning is an approachment which emphasized relevance from what is learned student in school with what he experienced in life daily. Contextual learning were removed the alienation in student mind with he learnt encountered in class. The instructional aids in learning were a learning media that demonstrate the way of an instrumentation work in a simple way. The contextual instructional aids will help student learn material with easier and simple. However thus , the existence of instructional aids still become constraint serious in learning physics (Masyruhan et al., 2020).

Recently, arduino become one of the important component that have been used on learning media to prepare 21st century skills , especially in implementing Science , Technology , Environment and Mathematics (STEM) approachment and learning Internet of Things (IoT) (Oprea et al., 2023). The forms of implementation in learning were: development of learning tools and learning resources, programming, and data analysis on the learning process in the technological era

(Abichandani et al., 2022). Arduino encourages connectivity between research, sensor applications and learning about sensor applications. Arduino has a relatively cheap price, is easy to develop and easy to obtain. Microcontroller Arduino is currently a teacher's favorite tool as a teaching aid, for example in demonstrate Light Emitting Diode (LED) with colors transformation, as well learning IoT in implementation sensors (Chandorkar & Shetty, 2019).

At high school level, arduino has been used as a component in learning media, including as instructional aids to explain and analyze kinematics (Jen et al., 2023), impulse and momentum (Indrasari et al., 2020), Newton's Second Law (Coban, 2020), and simple harmonics motion (Buachoom et al., 2019). As a demonstration tools in instructional purpose, an Arduino can also be used to demonstrate an ambient temperature sensor via a UI three color (Red , Green , Blue (RGB)) and two photo sensors resistor and thermistor (Nor et al., 2020)(Nor et al., 2020). Arduino is also has been used to develop free fall practical equipment (Rante et al., 2023), a water discharge measuring device (Wahyuningsih et al., 2019); moment of inertia teaching aid (David et al., 2023), light sensor teaching aid (Kinchin, 2020), doppler effect practical tool (Najahy et al., 2023). However, utilization arduino in automatic sprinkling system as the instrument to soil moisture measurement for high school level is still very rare found.

Based on existing problems , there was study that have been carried about about optimization system control humidity land IoT -based for support practice measurement physics class X (Annisa, 2024) . This study had been evaluated the value of accuracy, the instrumentation validation value in a way experimental, and the book of practicum guide's validation score. However, those study used ESP32 for microcontroller instead not Arduino. Those study also not yet either discuss the practicality of this instrument as instructional aids on students and their influence on motivation to learn physics. With take gap from problems and solutions that ever carried out by researchers before, then this study taken about analyze the student to automatic sprinkler instrument based arduino and humidity sensor, as tool show in learning physics in high school. This study aims become the preliminary study in research and development automatic system sprinkling based Arduino and humidity sensor, as an instructional aid to demonstrate the measurement of soil moisture, so can increase motivation in learning physics of students.

2. Methods

This study was a case study by used survey technique. This study was conducted to obtain a description and analysis of the students needs for developing the instructional aids of soil moisture measurement demonstration. This study was held in Senior High Public School Number 71 (SMAN 71) Jakarta, in May 2024. The population in this study were class X students of SMAN 71 Jakarta for the 2023-2024 academic year. The sampling technique was purposive sampling which 33 students in class XH at SMAN 71 Jakarta. The basic consideration of sampling was on the following considerations: 1) Students in class X were in adjustment phase from level previously to

high school, so still facing the study difficulty; and 2) The population student in class X has the same character, where there is no distribution class based on superior or regular, so the ability student considered to be equivalent.

The data collection technique of this study provide descriptions about the aspects that have studied were: students motivation to learn physics, curriculum analysis, student characteristics, and the media that frequently have been existence in class. This study was conducted through surveys and document analysis. Survey carried out on aspects: motivation in physics learning, student characteristics, and learning media analysis. Instruments that have been used in this study formerly tested validity content and reliability (Table 1), then used in data collecting. The content validity of the instrument is carried out by expert judgment. The reliability of the research instrument was tested using the Alpha Cronbach's formulation. After the reliability coefficient values have been obtained, then it classified in accordance category: very low (less than 0.200); low (0.200-0.399); moderate (0.400-0.599); high (0.600-0.799); and very high (0.800-1.00) (Rahmawati et al., 2022). Document analysis conducted to analyzing the physics high school curriculum and learning materials. Analysis document held by using qualitative metode, by with researcher alone as study instrumentation.

Table 1. Data collection techniques , validity , and instruments reliability on quantitative data

Aspect	Indicator	Instruments & Quantities Item	Method Validation, Categories Validity	Reliability level (r_{11}), Note
Motivation to Study Physics	Attention, relevance, confidence, satisfaction	Questionnaire, 8 items	Judgment validation, Valid with revision	0.758, reliable
Student Characteristics	Student learning styles (visual, auditory , and kinesthetic)	Questionnaire, 15 items	Judgment validation, Valid with revision	0.653, reliable
Student Needs in learning	Difficulty study physics, Students need for an automatic instrument practice in physics, Students requirement to recognize arduino	Questionnaire, 5 items	Judgment validation, Valid with revision	0.685, reliable
Instructional Media	The type of learning media that frequently found in learning process	Questionnaire, 1 item	Judgment validation, Valid with revision	

Data analysis techniques on quantitative data were carried out with a descriptive approach, using a post- positive paradigm, including : 1) Cause and effect; 2) Reduction to variables, hypotheses and specific questions; 3) Comparing measurement and observation data; and 4) Theory testing. Data collection on aspects of learning motivation, learning styles and student needs that have been used as research instrument built in form check list instrumentation. This check list instrumentation consists of a range of strongly agree (SA), agree (A), disagree (DA) and strongly disagree (SDA), with assessment scores SA=4, A=3, DA=2, SDA=1. Meanwhile, for determine the category of

learning motivation in physics, this study used standard deviation in according the past relevance study (Sari et al., 2018)

3. Result and Discussion

A. Motivation in Learning Physics

The level of student motivation in learning physics (Figure 1) is seen from: attention, relevance, confidence and satisfaction. Aspect relevance occupy for lowest percentage (55.30%) and then followed confidence (60.61%). Similar results have been found that the physics learning motivation level were lowest is relevance and confidence (Sari et al., 2018). The lower percentage level in relevance's aspect indicated weakness students on: a) ability to made correlation between concepts from learning material, and b) mentioning ability in physics concept application in daily life. The low level of relevance percentage indicates students unable find the linkages between what he learnt in class with what phenomena that he faced experience daily. Thus, teachers must facilitate contextual (relevant) learning with student phenomena life every day, so the student will not be alienated with the learning.

The low level of confidence aspect percentage indicated the student tendency to experience weakness in a) convey opinion or answer question, and b) resolve problem related material physics independently. The high level of attention and satisfaction in learn physics (Figure 1) apparently does not promote the confidence student in learning physics. The weak of student confidence also signify the student weakness in answer question when discussion being held. It could be possible if the students been tried for discovering the answer independently, but they unable to be brave to state his opinion. With so, teacher must facilitate learning where all student can direct for brave express his opinion.

Figure 1. Student's Learning Motivation in Physics Subject

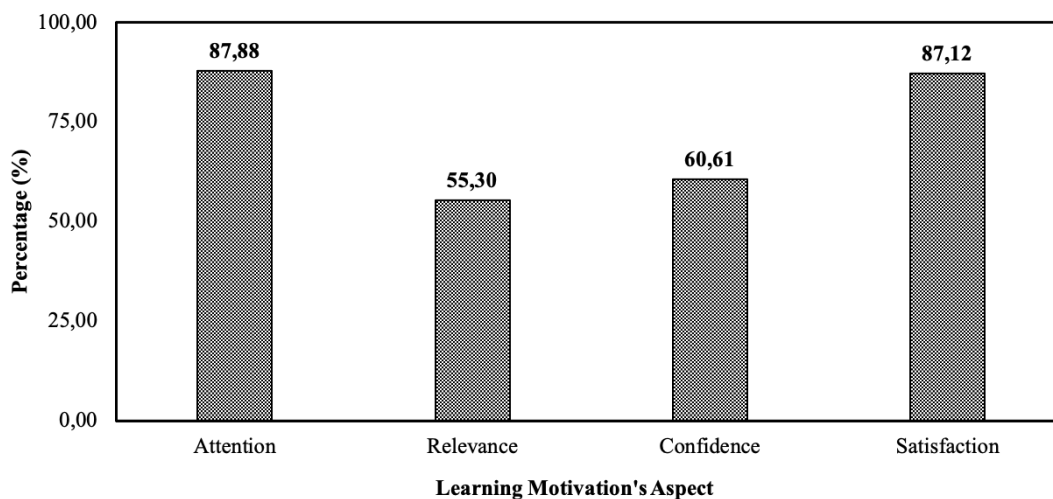


Table 2 Student's percentage based on motivation level in learning physics

Category	Amount Student	Percentage (%)
High	8	24.2
Moderate	21	63.6
Low	4	12.1

Table 2 shows the level of motivation in learning physics are in the category medium, similar with relevance research (Sari et al., 2018). This matter express motivation in learning physics has been not reach at optimal level. Physics still looked at as one of difficult and dos not evoke the enthusiasm. Whereas, the motivation in learning physics as the first trigger in psychology to push student stronger and willful for more information about physics. Motivation in learning physics will role in underlies the learning process, starting from conception of matter and phenomena, critical thinking, strategy of deep learn, up to successfulness in achievement learning physics. Motivation delivering student for own something ambition or objective in learning process. Based on that, teacher as facilitator must capable to awaken thir intrinsic learning motivation, because of the benefit in learning physics had been very important on student provision in life daily.

The influencing factors in learning motivation were: teacher learning model, learning media, school environment, and curriculum. Physics is a science that full consist of experiment activity in order to proving the concept, law, postulate and theory. In frame to increasing the motivation in learning physics , then curriculum of physics lesson should : 1) Directs teachers and students towards the process of inquiry for support performance student in learning physics ; and 2) Designed with load activity experiment or fun observation for students (Sari et al., 2018). This enhancement effort to increase the learning motivation also could be happen if the students also have internal awareness

for learning physics. The achievement in reach something objective will produce satisfaction and students will motivated for maintenance going try reach similar goals.

B. Analysis of Curriculum and Learning Materials

Analysis of curriculum had been carried for identify learning outcomes, learning objective and flow of learning objective. This analysis of curriculum would assessed the suitability between curriculum content and the content in teaching aids. Analysis of curriculum done through analysis document, particularly in “Kurikulum Merdeka”, which used recently in Indonesia. The curriculum that we analyze done in ten grade (phase E). This study also analysis the learning materials, by use the teacher instructional instrument, in form of module and lesson plan. According to achieve the learning outcomes, then learning process needs an instructional aid that can make student understand learning material with easy. In order to the system of sprinkling automatic that will used as instructional ads to demonstrate the soil moisture measurement. Analysis curriculum done in accordance in physics lessons: “Measurements” (Table 3).

Table 3 Analysis of Learning Outcome, Learning Objective, Flow of Learning Objectives, and Learning Materials

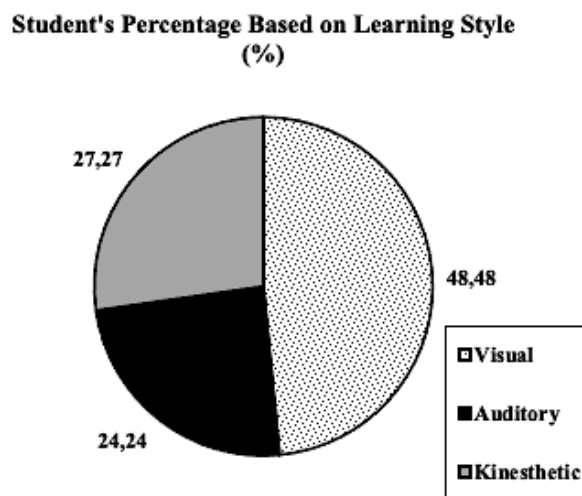
Aspect	Explanation
Learning Outcome	At the end phase E, participants educate own ability For responsive to global issues and their role active in give solution problem. Ability the including observing, questioning and predicting, planning and doing inquiry , processing and analyzing data and information , evaluating and reflection , communicating results in form project simple or visual simulation using application available technology related with energy alternatives, global warming, pollution environment, technology, nano biotechnology, chemistry in life daily use waste and materials nature , pandemic consequence viral infection. All effort the directed towards achievement objective sustainable development (Sustainable Development Goals/SDGs). Through development a number knowledge the also built with morals noble and attitude scientific like honesty, objective, reasoned critical, creative, independent, innovative, working together with global diversity.
Element Learning Outcomes	<p>Understanding Physics Student capable describe symptom natural pollution environment, energy alternatives, and their use.</p> <p>Process Skills 1) Observing; 2) Questioning and predict; 3) Plan and do investigation; 4) Processing, analyzing data and information; 5) Creating; 6) Evaluate and reflect; and 7) Communicate results in scope deep process skills measurement, change climate and global warming,</p>
Learning Objective	Understand draft measurement and application in daily life.
Flow of Learning Objective	Understand draft measurement and application in daily life, one of which is soil moisture measurment.

Analysis of material learning conducted by elucidation measurement lesson in sub topics, according flow of learning objective. Based on analysis of learning material, automatic sprinkling system which srduino based and humidity sensor will used as demonstrate soil measurement as instructional aid. In this lesson work, student will requested for doing repeatedly measurement on soil moisture measurement. This analysis of learning material then continued with student work sheet.

C. Characteristics Student Based on Learning Style

Virtual experiments influence mastery draft heat and its transfer to students with style auditory and kinesthetic learning, but does not had influenced with visual student (Hermansyah et al., 2021). Student with kinesthetic learning style experience most effective learning moment using the audio-visual media shown through enhancement results Study (Afolabi, 2021). Figure 3 shows most of student owning learning style by visual (48.48%), auditory (27.27%) and kinesthetic (24.24%). Student with visual learning style tend to easily remember something based on his eyesight, more understanding in something order than if read that. They even can enjoy reading although in the middle of commotion.

Figure 2. Student's Characterization Based On Learning Style



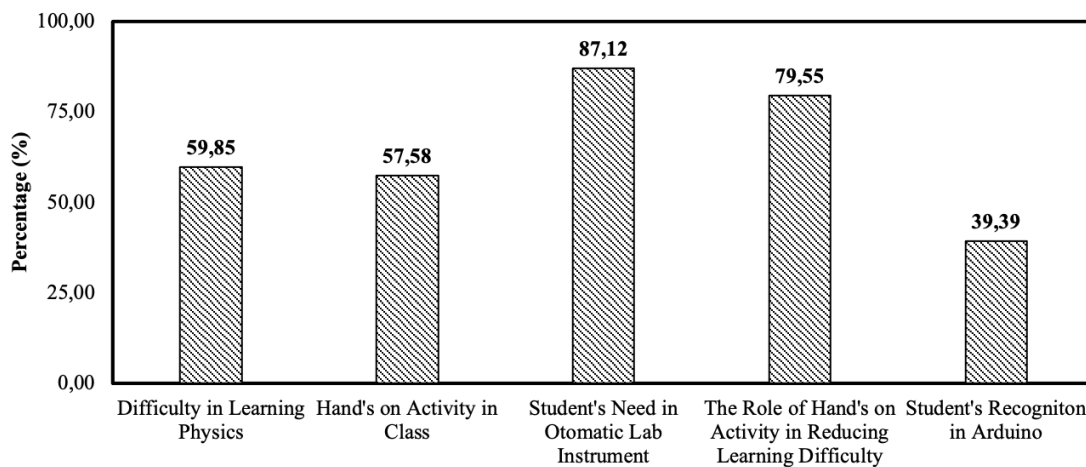
Student with auditory learning style were more dominant in used sense of hearing for learning activity. The student ho had auditory learning style experience difficulty when read material when his friends crowded inside class. They unable to concentrate if there be commotion. They even unable to focus if there is music playing with large volume. This matter caused by the student with auditory learning style use his ears as a learning medium, so if there is other sounds coming, it will destroy their learning focus so does they unable to concentration in study. Student with kinesthetic

learning style were easier in learning if they were move, touch, or take action. Student with kinesthetic unable to remember the learning material with memorize method, they optimize reach their learning when they are touching in a way physical, when speak with other people, even speak very slowly when currently do presentation in class.

D. Students Need in Learning

Need student in learning shown in Figure 2 express that most students (59.85%) experienced difficulty in learning physics and as many as 79.55% of students own confidence that hands on method of learning practice will reduce difficulty in learning physics.

Figure 3. Student's Need for Hand's On Activity



Basic Aspects Determining the Level of Student Needs in Hand's On Activity

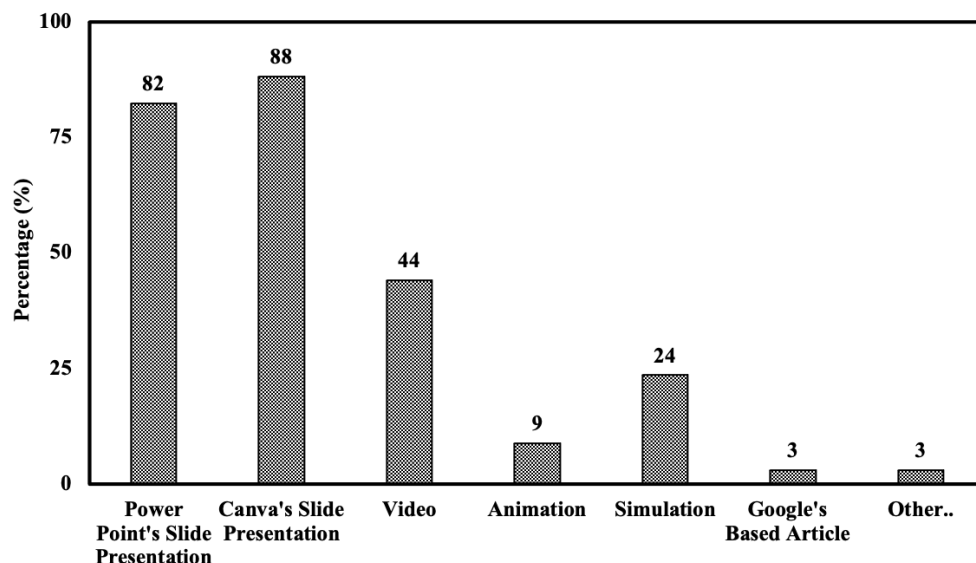
Meanwhile, the implementation of learning physics by practice method have been not optimized, only 57% of students agreed that practice have been done in learning physics. The limitation in experiment tool in laboratory still lack, shows by as much 87.12% of students agree that they need instrument practicum that has been done automated. One of microcontroller have been used in automatic laboratory experiment instrument system is Arduino. Arduino is cheap, simple, and easy to used, however only 39.39% of students have been recognize Arduino.

E. Frequently used learning media by students

Instructional aids has be one of the components that influence the process and results learning. Figure 4 shows the most frequent learning media used, they ware power point slides, then followed

with presentation canva's slide presentations, videos, simulations, animations and articles from Google. This learning media still lack of variety, it limited in to audio-visual media form. Those medias been not yet involved tactile sense, which can obtain from 3 -dimensional media, one of them in form demonstrate instructional aids.

Figure 3. Variety Type of Learning Media in Class



The student need of learning media in form of three dimension that can demonstrate the way of work from a tool or a phenomenon, has been supported by another research in past. Only with watch the video, students have no experience significant change to motivation in learning physics (Yusnanto & Rahayu, 2022). Learning inquiry must use the appropriate learning media, which suitable with learning style, will influence the learning achievement in physics instructional aids, as learning media, were needed to be deep learning, so the learning become not too verbal, so can grow enthusiasm student for construct his knowledge independently (Istiqomah et al., 2022). Arduino also can be used as microcontroller system positioning local as a learning medium material kinematics , dynamics rotation (Syahril et al., 2022) .

4. Conclusion

The level of student motivation in learning physics at SMA N 71 was categorized as “medium”. Student showed high level in attention (87,88) and satisfaction (87,12), but lower percentage of relevance (55,30%) and confidence (60,61%). So that required effort for carry out a contextual and

improving learning process participation active every student in learning. The analysis of curriculum and learning materials show that the system of automatic sprinkling by arduino based and humidity sensor can be used as an instructional aid, to demonstrate the soil moisture measurement. In accordance “Kurikulum Merdeka” and contextual learning approach, the sprinkle system can be utilized for expand the measurement lessons in class X. Students can do the repeatedly measurement in soil moisture. Characteristics of student in accordance learning style X SMA N 71 were dominated by visual learning style (48.48%), followed by kinesthetic (27.27%) and auditory (24.24%). Motivation of physics learning can be improved in accordance with learning style and instructional aids can accommodate those third learning style.

The domination of student experience difficulty in learning physics and agree that do practice can help they in overcome learning difficulty. The frequently of hand’s on activity or practice method had been not optimize and students agree that they need practice with automated instruments in laboratory. There are only some small studenta that have been already know Arduino. Learning media that have been used frequently in class still dominated by audio-visual media, in the form of power point slides occupied the highest percentage, followed by canva’s slide presentation, videos, simulations, animations and articles from machine search google. This unoptimized of learning media application especially in demonstrate instructional aid and the lack of amount of the automatic experiment instrument in lab, they both support for research and development system sprinkling automatic as tool show measurement of soil moisture in class X at high school.

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