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Recycled material-based science instruments to support science education in rural area at Central Sulawesi District of Indonesia

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Abstract. It has been successfully designing low cost of science experiment from recycled materials. The science instruments were produced to explain expansion concept and hydrostatic pressure inside the liquid. Science instruments were calibrated and then validated. It was also implemented in science learning.

1. Introduction
Most of physics science concept studied in Senior High School was abstract [1-2]. It makes the student got difficulties when learning without media (instrument). Their motivation, activity, and result of studies were decreased. This situation is not conducive and alternative solutions were needed.

In Central of Sulawesi (Indonesia), most of Senior High School is placed isolated region. Experiment equipment (KIT) was not available properly. The teacher used direct instruction methods when they teach science concept. As the result, science concept can not understand the student.

In this paper, we developed science instrument for senior high school in Central Sulawesi. Low-cost materials were used to design it. The result of this study was expected to support the science education in Indonesia.

2. Methods
In this study, science instruments were developed for pressure and heat transfer concept. Borg and Gall's methods were used by implementing five step: (1) designing, (2) making, (3) revising, (4) implementation and (5) socialization [3-4]. Instruments were validated by two experts. Revising were done according to their recomendation [5]. Then, science instruments were tried in senior high school in Sigi and Donggala District. The instrument then socialized in physics teacher association in both districts.

3. Result and discussion
These studies aim to develop science instrument by the used low-cost material. Creativity is required to design it. Science instrument is shown in Figure 1 to 6 [1]. These instrument has been tested in three aspects, i.e. validity, effectiveness, and practice. All aspect of developed science instrument was corrected by two experts. It was found that our designing instrument was in a good category.
Figure 1. The simple science instrument for liquid (a) and gaseous (b) expansion concept

Figure 2. Simple science instrument for solid expansion concept

Figure 1 shows a simple science instrument explained the expansion of liquids and gases. In Figure 1(a), heated bottle contained red water and it will be expanded to indicate expansion of the liquid. Then, in Figure 1b, when the temperature in heated bottle increase the balloon will expand.

Expansion phenomenon of solids can be observed in Figure 2. If the metal rod was heated, length expansion can be observed. Then, the edge of the rod will push the pipette and it will move up. The higher the heating temperature, the huge expansion experienced by the metal being indicated by the increase in the pipette.

Figure 3. Simple science instrument on the concept of heat transfer by conduction

Figure 4. Simple scientific instruments on the concept of heat transfer by convection

The instrument in Figure 3 is made by applying the principle of heat transfer by conduction. The process can occur due to temperature differences that commonly occur in solids (metals). The heating is done at one end of the metal will cause melting wax affixed. Candles closer to the heater will melt faster than the candles that were located further away from the heater.

Convection is heat transfer followed by displacement of the intermediary substance. These events can be observed through a demonstration by using a science instrument in Figure 4. To illustrate the process of convection, in a biscuit tin placed a heater/candle and a mosquito repellent that has been burned. Mosquito coil is placed right under the pipe (left) which serves as a chimney while the candle is placed just below the chimney right. At the beginning of this experiment, the smoke of mosquito coils will come out of the chimney left. However, after the temperature of the chimney right-hand goes up, because the heating, the smoke will come out of the chimney. The exit of the smoke through a chimney that has a higher temperature describes the process of convection, which can be identified with the events of daily life as the sea breeze and land breeze.
The process of heat transfer via radiation or emission can be observed by means of a simple science instrument in Figure 5. The instrument in Figure 5 can be used as a heat source from electrical energy or the source of sunlight. The black lights were can receive more heat energy than white lamps. If the heat of light increase then the position of liquid in U form will be changed.

![Figure 5. Simple science instrument on the concept of heat transfer by radiation](image1)

![Figure 6. Simple science instrument on the concept of pressure on the liquid](image2)

Each point on the liquid that is placed in a specific container pressure. The magnitude of this pressure varies according to the position. Variations of the pressure on the liquid can be observed by using the tool in Figure 6. Where the rubber stopper when the bottle is opened, the water contained in the bottle will come out. The water flow rate varies depending on position/position.

Science instrument has been designed and it can be used for learning science. Some trial implementation of learning science by using this tool has done and show good results. Implementation of these media has been conducted in School as shown in Figure 7.

![Figure 7. Implementation of learning by using science instrument: (a) Teacher organized the student in the small group, (b) The teacher demonstrates the use of science instrument, (c) Student used the science instrument for the experiment, (d) Teacher discuss with the students.](image3)
After learning by using science instrument, students then evaluated using the form of multiple choice questions. Results of the evaluation of students’ science learning in schools located in the district of Sigi and Donggala.

The trial results showed an increase in student learning outcomes significantly, with the average of the results of the post student test of 8.44. The activity of students during the learning process is very good (> 90%). Students are very happy with this learning model that can increase interest in learning. The high activity of students is not only due to the science experiments with the tool but also because of the activity of the discussion in the group as well as the appreciation of teachers.

To disseminate the idea of using science instrument, the team has been socialized in a few schools in Sigi and Donggala District, Central Sulawesi. In carrying out the socialization of the researcher in collaboration with the Physics Teacher Association. Dissemination is documented through photographs in Figure 8.

Through socialization obtained some information about the state of science teaching in senior high schools. Among known that the availability of science instruments in schools is still lacking. In addition, based on the analysis of the results of questionnaire respondents socialization participants note that most of the teachers (about 96%), quite predominantly use the lecture method in teaching science because of the unavailability of teaching media in the form of a science instrument. Therefore, this has resulted in the acquisition of student learning outcomes to be low. The presence of recycled materials based science instrument is expected to overcome a number of problems faced by teachers in learning science. This study can be applied in a rural area at Donggala and Sigi district. As a comparison, Rediansyah et al [6] reported that simple science instrument in electric field concept has been developed by using mosquito racket and baby oil [6].

In the implementation of socialization also conducted demonstrations manufacture and use of a science instrument. Through cooperative learning simulation with science instrument in socialization is known that about 98% of participants considered that the science instrument attractive design, presented in a systematic and fit for use as an instrument of learning science. Therefore, through the socialization of science learning instrument is known that most teachers are interested to develop recycle material based science instrument. Thus, the knowledge about the use of a science instrument used goods is one solution to improving the quality of science teaching in senior high school [7-9].

Widiatmoko et al [10] also developed simple spectrometer using the common material for observing wavelength. Furthermore, a simple experiment can also be done by simple media [11-14]. On the other hand, physics concept, for example, solar cells [15-17], also need an instrument for teaching in high school.

![Figure 8](image-url). Dissemination of science instrument at teacher association: (a) District of Sigi, and (b) the District of Banawa.
4. Conclusion
Science instrument for some concept in science has been successfully designed and developed. The implementation of this study showed that understanding concept of the student was increased significantly.

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