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The Aspects and Changes of Students' Environmental Science Agency in the Action-oriented Science Education Program Using Physical Computing and Internet of Things

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The Aspects and Changes of Students' Environmental Science Agency (ESA) framework of analysis in the Action-oriented Science Education Program (AOSE) initiative Using Physical Computing and Internet of Things (IoT) technology

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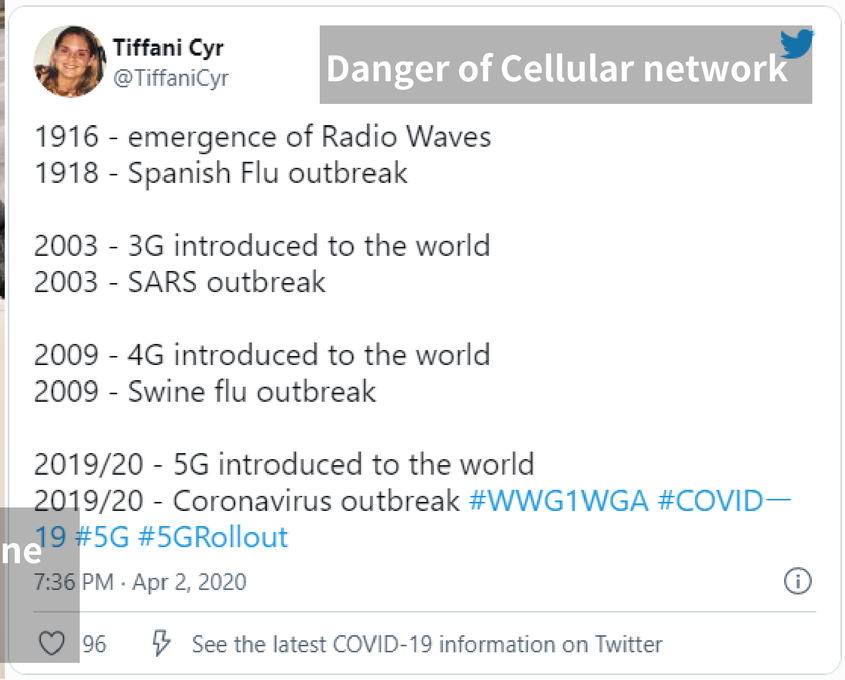
Why did we do this research?

Needs of Civic Participation

- Civic participation in the SSI is emerging as a reaction to technocracy (Beck, 1992).
  - Because scientists are stakeholders in scientific decisions, they are not free to their interests (Betz, 2013).
  - Uncertainty is inherent in science (Kostas & Kevin, 2019).
- In COVID-19 pandemic, the needs civic participation is more emphasized.
  - “Citizen science informs research questions, data collection and analysis, and conclusions that can impact the quality of life in local environments.” (Provenzi & Barello, 2020)
- Therefore, **science education should develop the students’ competences of participating science-related decision**.

Fukushima Daiichi nuclear disaster (11 March 2011)

Safety of COVID19 Vaccine (December 2019 ~)



What kind of education is needed?

Action-oriented Science Education (AOSE)

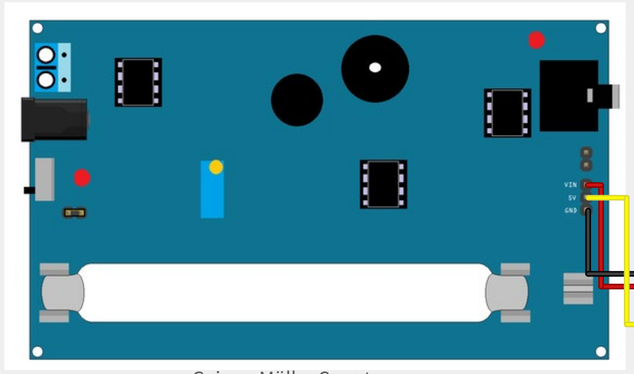
- Current educations, such as STS or SSI-oriented science education, are insufficient to cultivate **the competence for civic participation**.
- A much more politicized approach is advocated, with major emphasis on social critique, values clarification, and sociopolitical action (Hodson, 2010).

Example of AOSE : STEPWISE Program (Bencze, 2017).

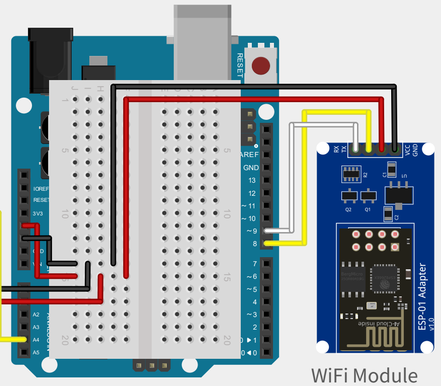
“How can students detect the concentration of fine dust, sulfur dioxide, carbon dioxide, and so on?”

Coal-fired Power Plant in Chungnam, Korea

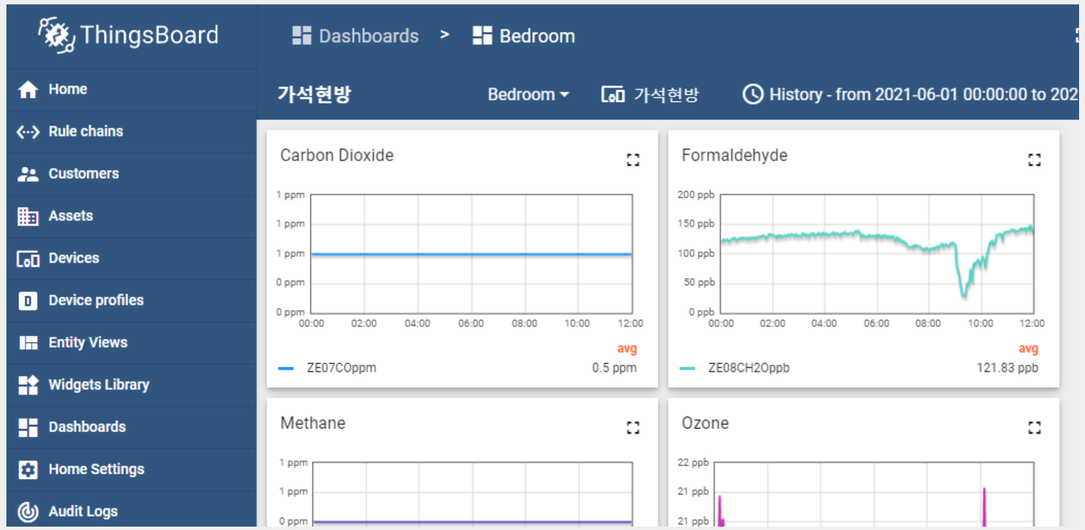
Radioactivity Meter



Geiger–Müller Counter



WiFi Module
(ESP-01)



Tools for student-led inquires in AOSE

Do It Yourself Measurement Devices (DIY-MD)

- DIY-MD is **a measurement device using Physical Computing and the Internet of Things**, which can be made by the student and customized as their inquiry settings (Ga et al., 2021).
- Arduino-based DIY-MD makes students detect **various targets** for their inquiries through sensors sold in Internet markets **at a low cost**.
- By connecting wireless communication modules, such as Wi-Fi or LTE modules and sending data to IoT Platform, the student can do **remote sensing, database management, and data visualization** in IoT Platform.

Research Question

“How did aspects and changes of students’ ESA appear in the AOSE program using DIY-MD?”

Instructional Design

AOSE Program

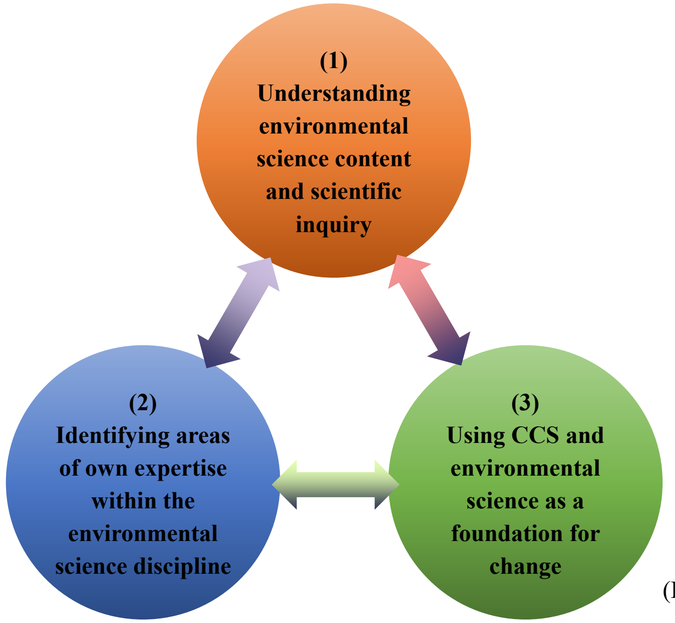
- 8 weeks (24 sessions), 50 mins per one session
- Participants: 5 Undergraduate Students in College of Education (4 men, 1 woman)
- Schedules
  - 1~4 Weeks: How to make DIY-MD
  - 5~8 Weeks: Student-led Project for Solving Environmental Problems

Weeks (Sessions)		Contents	Type
Part 1	1 (1~3)	• What is Physical Computing and Internet of Things? • Principle of electrical signal (digital and analog signal) • Digital input/output (blinking LED, resistance and breadboard, serial monitor)	Group
	2 (4~6)	• Analog input/output (variable resistance, photo resistor, thermometer) • Coding via Arduino library (ultrasonic Sensor, servo motor) • Various application of Arduino (including LCD module)	Group
	3 (7~9)	• Sensors and actuators (Including DHT11 sensor) • Connecting to the Internet using Wi-Fi module (ESP-01) • Analyzing data stored in the IoT Platform	Group
	4 (10~12)	• Making DIY-MD for their interest sensors • Noticed the project which will be done in Part 2 • Introducing example of projects all over the world	Group
Part 2	5 (13~15)	• Sharing students' research plan • Revising research plan • Mutual feedback	Group
	6~8 (16~24)	• Making DIY-MD for their inquiry • Collecting and Analyzing Data • Planning for Social Action • Taking Action	Individual

Analysis Framework

Environmental Science Agency (ESA)

- The ESA is stemmed from the critical science agency of Basu & Calabrese Barton (2009, 2010).
- It reflects the context of environmental conservation and science, which means **“the capacity to influence the surrounding world for the environment.”**
- As students are seen through the lens of ESA, they are not just passive beings who have to adapt to school culture and norms but active beings who actively reproduce and change school culture and norms.

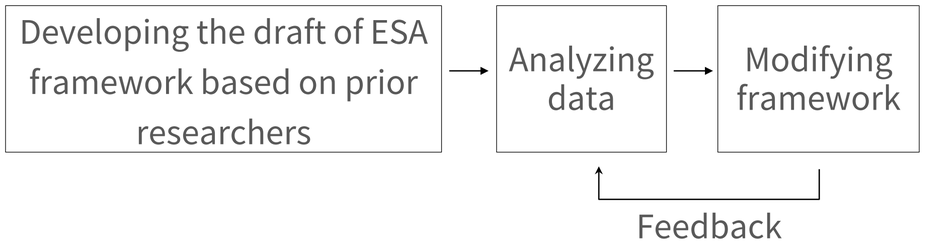


(Ballard et al., 2017)

Data Analysis

Developing Framework & Data Analysis

- Development of the framework and data analysis had done simultaneously.
- Modifying the framework of Harris & Ballard (2021) according to the data in this research



Framework of Environmental Science Agency

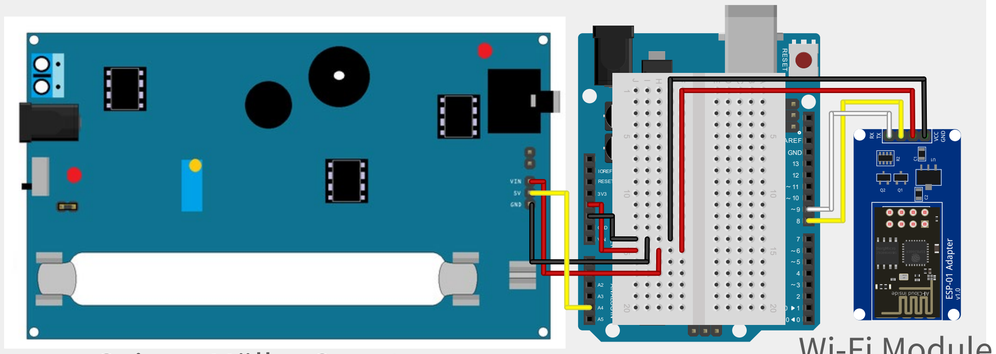
Components	Categories
Understanding	• Understanding content knowledge related to environmental science
Positioning	• Recognizing environmental problems as their own
	• Recognizing oneself as an actor in solving environmental problems
Extensionality	• Sharing their research results with others
	• Extending their experience to a new environment/context

Case Description

Student Y

- Sophomore majoring in earth science education
- Graduated from a public high school in a small city
- Topic: **the harmfulness of PAL-XFEL** (Pohang Accelerator Laboratory X-ray Free-electron Laser)
- Action Plan: To inform the danger or safety of PAL-XFEL to the local community
- Results: The level of Geiger-Muller Counter near PAL-XFEL is **not significantly different than other areas**.
- Student Action: Undone
  - He thought it was not meaningful to inform the safety of PAL-XFEL to the local community.

Radioactivity Meter



Geiger–Müller Counter

Wi-Fi Module (ESP-01)

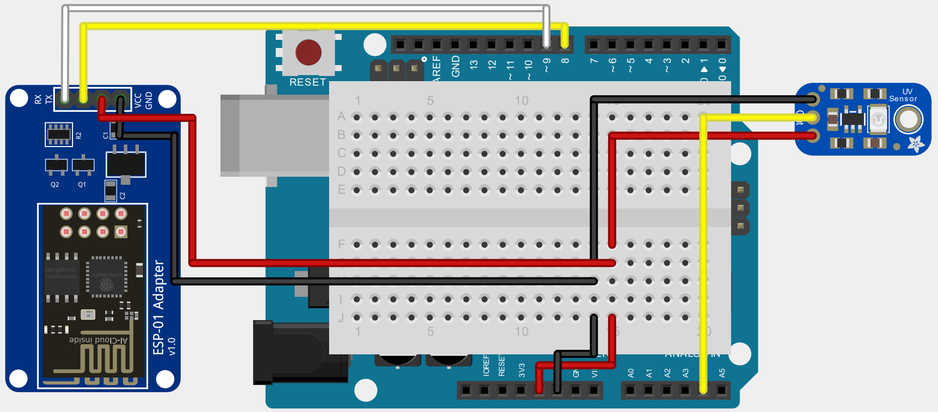
- Sensor: Geiger-Muller Counter
- Targets: X-rays, γ-rays

Case Description

Student J

- Sophomore majoring in earth science education
- Graduated from a public high school in a provincial metropolitan city (廣域市)
- Topic: **Danger of Indoor UV rays**
- But he was living without caring UV rays.
- Action Plan: To inform whether the danger of indoor UV is harmful to netizens on the Internet
- Results: Even if very strong light comes in from the outside, UVI is low if the window is closed.
- Student Action: Uploading the card news in Facebook, Sharing his card news with his middle school friends.
    - He was proud of his achievement.

UV Index Meter



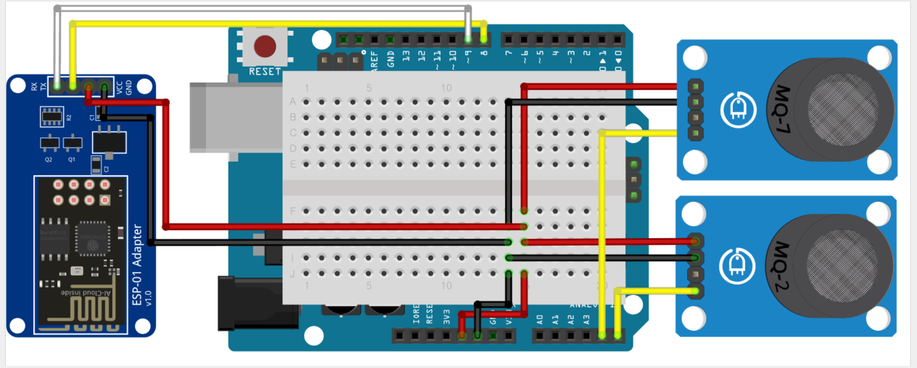
- Sensor: CJMCU-S12SD (UVI Index Sensor)
- Targets: Ultraviolet rays

Case Description

Student P

- Sophomore majoring in earth science education
- Graduated from a public high school in a small city
- Topic: **Street Secondhand Smoking**
- Action Plan: Ask the university authority to setup smoking booths
- Results: Unreliable data was collected due to technical problems.
- Student Action: Undone
  - She didn’t want to take action without data supporting her claims.

Smoke Detector



- Sensor: MQ-2, MQ-7
- Targets: smoke, carbon monoxide

Results & Discussion

Components	Category	Aspects*	Changes
Understanding	• Understanding content knowledge related to environmental science	• Searching media (newspapers, blogs) for environmental science information (Y, J) • Exploring expert-level scientific knowledge (Y, P)	• **At the beginning of the project, students started with a layman level of knowledge but gradually explored expertise as needed, as the project activities progressed.**
Positioning	• Recognizing environmental problems as their own	• At the beginning of the project, there were students who thought their topic was their problem (P), and others who weren't (Y, J) • Through the project implementation, Students perceive this topic as an important issue that can affect them (J, P)	• **As the project progressed, students had been perceived the topic as their problem.**
	• Recognizing oneself as an actor in solving environmental problems	• At the beginning of the project, students don't think themselves as an actor to solve problems (Y, J, P) • Obtaining meaningful data has a significant impact on recognizing themselves as an actor of solving problems (Y, J, P) • Through the project experiment, the student recognized that he could make a change using DIY-MD (J)	• **Students recognized himself as an actor of environmental problems by securing his own meaningful data.**
Extensionality	• Sharing their research results with others	• Sharing the results of the experiment with the people in this class and receive feedback (J) • Creating and posting card news on Facebook to inform the public (J) • Student J shared his card news when the indoor UV issue was mentioned in the KakaoTalk chat room composed of middle school friends (J)	• **Students first took action for societal changes using science.**
	• Extending their experience to a new environment/context	• Developing the ability to solve new environmental problems using DIY-MD based on project experience (Y, J, P)	• **Students have the ability to participate in environmental problems using DIY-MD.**

* Y: Student Y, J: Student J, P: Student P

Through this research, we found that

This AOSE program using DIY-MD developed the students' ESA

Understanding

- At the beginning of the project, students started with a layman level of knowledge but gradually explored expertise as needed, as the project activities progressed.

Positioning

- As the project progressed, students had been perceived the topic as their problem.
- Students recognized himself as an actor of environmental problems **by securing his own meaningful data.**

Extensionality

- Students first took action for societal changes using science.
- Students have the ability to participate in environmental problems using DIY-MD.

Conclusion

- Having meaningful data makes students become an actor.
- DIY-MD makes having data possible.
- Through this program, students become informed social actors who take action for making a better society.

Thank you

More information

- Homepage: http://seokhyun.ga
  (Most of them in Korean, but Google Translator helps you!)

- Ga, S.H., Cha, H.J., Kim, C.J. (2021). Adapting Internet of Things to Arduino-based Devices for Low-Cost Remote Sensing in School Science Learning Environments. *International Journal of Online and Biomedical Engineering* 17(2), 4-18. https://online-journals.org/index.php/i-joe/article/view/20089

Do you have any questions?