The Methodology of Developing the Urban Heat Island e-Module on the Achievements and Collaboration Skills of High School Students in Surakarta

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# The Methodology of Developing the Urban Heat Island e-Module on the Achievements and Collaboration Skills of High School Students in Surakarta

**Siti Azizah Susilawati[1], Mohd Hairy Ibrahim[2], Nor Kalsum binti Mohd Isa[3], Norwaliza Abdul Wahab[4], Muhammad Musiyam[5], Agus Herianto[6], Nurin Rochayati[7]**

[1,5]Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta, Indonesia

[1-4]Fakulti Sains Kemanusiaan, Universiti Pendidikan Sultan Idris, Malaysia

[6,7]Faculty of Teacher Training and Education, Universitas Muhammadiyah Mataram, Indonesia

## Abstract

Nowadays, Urban Heat Island (UHI) occurs in big cities worldwide. The UHI phenomenon needs to be introduced in school because this phenomenon occurs around the students. Surakarta, one of the big cities in Indonesia, has been threatened by the UHI phenomenon, so enrichment materials related to the UHI phenomenon are needed for students in schools. This research will develop the UHI e-module as an enrichment teaching material on the impact of global climate change and research on climate and its utilization. This paper aims to present an e-module development research methodology on UHI based on the phenomenon of UHI threats in Surakarta City and its effect on student achievement and collaboration skills. Design and Development Research (DDR) uses the Borg and Gall model. The methodology of the research development is divided into three phases: the needs analysis phase, the design and development phase, and the implementation and evaluation phases. The difference in this research is the geographical space-based study approach in the development of material based on the UHI phenomenon in Surakarta City and urban and rural spatial sampling techniques.

**Keywords:** collaboration skills, design and development research, e-module, urban heat island

*Corresponding Author:*
*Siti Azizah Susilawati, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta, Indonesia*
*Email: azizah.susilawati@ums.ac.id*

## 1. Introduction

Nowadays, many cities in Indonesia are threatened by urban heat island (UHI), but some school students did not know about the urban heat island phenomena that occur around them. UHI is one of the impacts of environmental change in urban regions. UHI is a phenomenon that happens when urban temperatures are higher than in rural areas (Masumoto, 2015; Mohajerani, Bakaric, & Jeffrey-Bailey, 2017). UHI impact is restrict-ed to anthropogenic atmosphere change in the shade layer of the urban climate where practically all everyday human activities occur (Buchin, Hoelscher, Meier, Nehls, & Ziegler, 2016). UHI research is widely carried out worldwide, but there is little research on UHI in education. UHI learning in schools is essential to introduce the phenomenon to people and students. Ana Maria stated that more than 3700 distributed papers in the field were identified in the Web of Sci-

ence Database from 1989 until 2016 (Maria et al., 2016). The more significant part of them was written in Meteorology, 26% of the identified papers, Environmental sciences (19%), and Engineering (11%). They are followed by documents written in building technology, energy, photographic technology, and physical geography. Although all the investigations are identified with urban structures, just 5% of all the composed papers were published in urban studies-related jour-

nals, bringing this topic to the 10th spot on the list (Maria et al., 2016). UHI is one of the phenomenons of climate change impacts, but UHI has not been introduced at school. Meanwhile, the UHI has threatened a few major urban communities in Indonesia. Figure 1 gives information that UHI occurred in Indonesia recently. The researchers measured UHI phenomena and only a few studies the UHI mitigation.
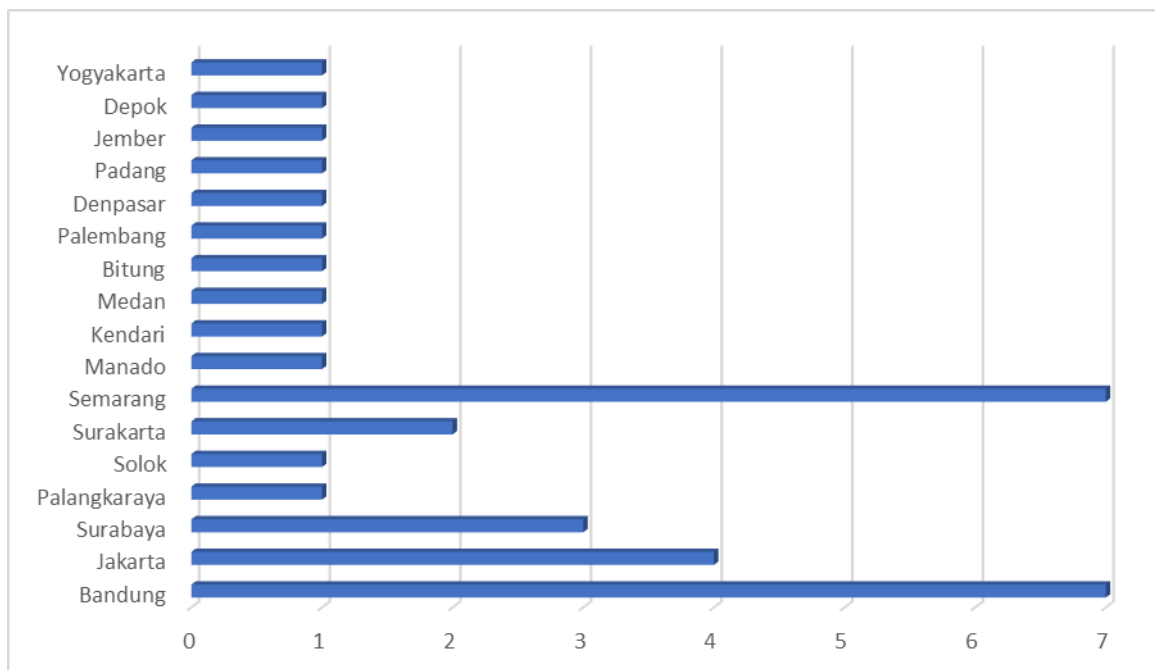


**Figure 1. UHI Research in Indonesia Based on the Research Location**

Research on UHI has been carried out in various big cities in Indonesia. The study was conducted in the following cities based on the literature review on 36 journals over five years from 2017-to 2021 (figure 1). Figure 2 shows that studies on UHI mainly were studied in the cities of Bandung and Semarang, followed by Jakarta, Surabaya, and Surakarta, respectively. Based on the

theme of UHI studies that have been carried out in various cities in Indonesia, 72% are dominated by the theme of UHI studies through the Geography Information System approach, 8.3% on the Community Land Model and water balance approach, 5.6% on the theme of mitigated through vegetation and 2.8% of land use. Change and UHI Mitigation, respectively.
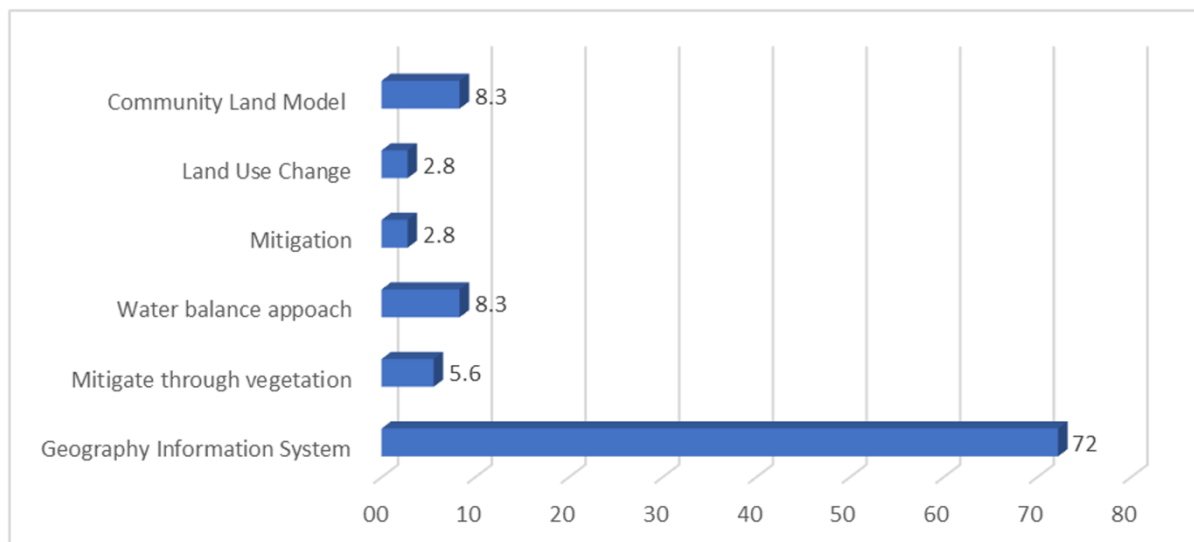
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**Figure 2. UHI Research in Indonesia Based on Theme**

UHI can be introduced to students through geography in the essential competencies of atmospheric dynamics. UHI has not been included in the textbooks, so dependent on the Regulation of Education Ministry of Indonesia. Regulation of Education Ministry of Indonesia No. 2, article 6 themes are utilization of the book in education units, (1) textbooks are utilized as a compulsory reference by educators and students in the process of learning, (2) in addition to the textbook as referred in item 1, educators may use educator manuals, e-module, and reference books in the process learning, (3) to expand student's knowledge and insight, educators can encourage students to read e-module and reference books. UHI can be acquainted with students through geography, and the knowledge can be through UHI E-module. UHI E-modules are books that contain enriched material from textbooks at the primary and secondary education levels. The UHI E-module improves students' thinking skills and broadens their viewpoints on the environment based on the latest knowledge. The current concept of learning in Indonesia, from traditional teacher-centered learning to student-centered learning, needs to be supported by implementing Information Technology in Education (Fitriansyah, Fatinah, & Syahril, 2020). One of the applications of information technology in education is the teaching media module developed into an e-module. Other than a decent substance, the UHI E-module must also be presented excellently to foster students' interest in reading. UHI e-module is needed to open students' insights into UHI that happen around them and encourage them to take real action regarding their condition in the environment.

Gall argues that a digital module (e-module) is a significant improvement preference because the traditional one (printed module) which much less interactive and has a static or monotone pictorial show (M. D. Gall, 2003). On the other hand, e-module can interactively gift substances featured through multimedia, including videos, animations, simulations, and queries with immediate feedback. Furthermore, e-module helps minimize the number of intrinsic and extrinsic cognitive loads, facilitating the externalization of information thinking, memory, and processing. Learning content will be more dynamic, effective, and entertaining. The use of multimedia is considered suitable for improving learning outcomes (Irwansyah, Lubab, Farida, & Ramdhani, 2017). The ad-

vantages of e-module are also stated by Lin (Lin et al., 2015), e-module is an exploratory and unique study media because the computer is programmed to become a collaboration agent.

Modules as teaching materials are currently being developed digitally in e-modules. E-module is an adaptation to advances in educational technology. E-module is an information and communication technology (ICT) -a based module that is interactive because it is easy to navigate, has a variety of image, audio, video, and animation displays, and provides feedback through specific formation tests and quizzes (Sugihartini et al., 2017). E-module development can improve students' knowledge and learning outcomes (Azis, 2021; Gustria & Fauzi, 2020; Ilmi, Arnawa, Yerizon, & Bakar, 2021; Istuningsih, Baedhowi, & Sangka, 2018; Sitorus, Siswandari, & Kristiani, 2019; Suwatra, Suyatna, & Rosidin, 2018), e-module can also improve collaboration between students. The student should be included and responsible for the improvement that he has made in terms of his education. Among the teaching-learning strategies are those through which students work productively with one another and develop collaborative skills and mutual help. They can have a gigantic on students because of their names and playability and provide children's learning alternatives. We should use, above all, some active-participative strategies, creative to create critical thinking in students (Ciobanu, 2018). Collaboration is a valuable tool used within a participatory culture as an ideal educational Outcome. The Partnership for the twenty-first-century Skills, for example, defines collaboration as working viably and intentionally with differing groups, practicing adaptability and a willingness to make compromises to achieve a common goal, and accepting shared responsibility for collabora-

tive work while valuing individual contributions (Chu, Reynolds, Notari, Taveres, & Lee, 2018).

This research aims to design and develop the UHI e-module with a design and development research approach. The other purpose is to determine the influence of the UHI e-module on student achievement and collaboration skills. The development of e-modules as learning media can improve student achievement, as seen from the pretest and post-test results on the effectiveness test (Irwansyah et al., 2017; Sendari et al., 2019; Utomo et al., 2020). The advantages of the e-module support this increase in terms of readability, clarity of presentation, and the attractiveness and usefulness of the results. Meanwhile, the development of e-modules that can improve students' collaboration skills is carried out by (Mustari, Marwoto, Iswari, Ginanjar, & Anjelinar, 2020), modules based on collaborative teamwork learning models were declared very feasible and received a positive response as a learning media. The benefits of educational technology help students collaborate through visual collaboration Substitution allows students to solve problems together. Educational technology helps students collaborate effectively, including through scripts for collaboration (Rau, Bowman, & Moore, 2017). This e-module is a technical learning media with collaborative worksheet activities created according to the needs assessment in the first research stage.

## 2. Method

Design and Development Research (DDR) in education has been improving to develop a few domains in education. For education domains, curriculum, media and technology, learning and instructional, and teacher and didactic are often objects of development research (Akker, 1999).

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Research and Development is research about strategy utilized to create particular products and test the legitimacy of these products. Research and Development contain steps to create unused products or move forward with existing items, which can be accounted for (Saputri, Sukirno, Kurniawan, & Probowasito, 2020). Research method DDR develops instructional and non-instructional products and new or improved models and tools. Richey expressed that DDR is the systematic study of design, development, and evaluation processes to establish an empirical basis for creating instructional and non-instructional products and tools and new or improved models that govern their development (Richey & Klein, 2014). Richey & Klein detailed two types of studies in development studies: reflections of a specific product or program design, development, and evaluation projects. The second is the study of processes, tools, or models of a new design, development, and evaluation procedures and potentially models.

DDR is a systematic study separates into four phases namely, 1) needs analysis phase, 2) design and development phase, 3) implementation and evaluation phase. This research is the design and development research of the UHI E-module in Surakarta using Borg and Gall model. Borg and Gall expressed that "educational" research and development, R and D, develop and validate educational products (Gall, Gall, & Borg, 1983). Borg and Gall clarified that the steps of this process are ordinarily alluded to as the R & D cycle (Figure 1). It comprises studying research discoveries applicable to the Product to be developed, developing the products dependent on these findings, field testing it in the setting where it will be utilized eventually, and revising it to correct the deficiencies found in the filed-testing

stage. In increasingly thorough programs of R & D, this cycle is repeated until the field-test data demonstrate that the Product meets its typically characterized defined objectives (Gall et al., 1983).

Borg and Gall stated that this process's steps are usually referred to as the R & D cycle. This research comprised of studying research discoveries appropriate to the Product to be developed, developing the products dependent on these findings, field testing it in the setting in which it will be used eventually, and changing it to address the deficiencies found in the filed-testing stage (Gall et al., 1983). Progressively through programs of R & D, this cycle is repeated until the field-test data indicate that the Product meets its behavioral characterized objectives.

The need analysis phase is the stage of recognizing why an e-module is required. The UHI e-module was made expecting to provide students with the knowledge through achievement students and increase the collaboration skills of the presence of and UHI phenomenon that is relatively new and not yet well-known by students. Need analysis divide of literature review, identification of UHI threat in Surakarta by NDVI (Normalized Difference Vegetation Index) and LST (Land Surface Temperature) estimated, document analysis, expert/teacher interviews, and the problem teacher questions.

The design and development phase of this research is the phase of developing the UHI e-module partition of (1) E-module planning, which separates determining e-module indicators, deciding learning outcomes, creating instruments, and validating and reliability instruments; (2) Developing a preliminary form of Product which partitions of developing the initial UHI e-module, developing learning material,

design learning process, design evaluation instruments, and expert validation; (3) Preliminary field testing separate phases of a pilot study to take preliminary field testing, validate evaluation instruments, and validate the UHI e-module by teacher and students; (4) The product revision step is the improvements in the initial e-module (revising the UHI e-module); (5) Main Field Testing is the progression which it conducts significant field tests for UHI e-module.

The implementation and evaluation phase is when the UHI e-module implementation at school and to get the evaluation based and field/school. This phase separation of (1) Operational Product revision is the stage that Improvements to more comprehensive trial results e-module (revising the UHI e-module; (2) Operational Field Testing is activities of validation of the functional UHI e-module that has been produced, experts validation, and rehabilitation, and effectiveness UHI E-module; (3) Final E-module Revision is the final UHI e-module revision; (4) Dissemination and implementation is the last step which its dissemination and implementation of UHI e-module.
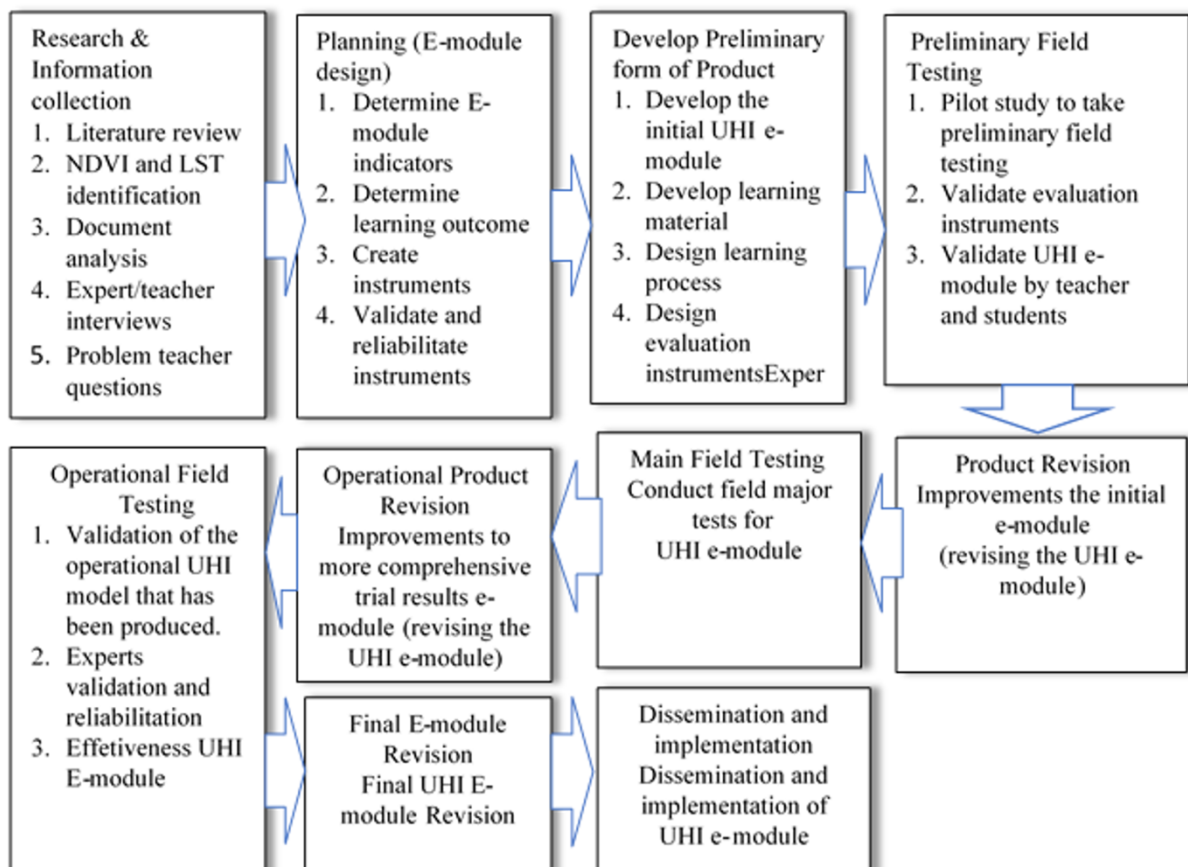


**Figure 3. Stages of e-Module Development using the Borg and Gall Model**

## 3. Result and Discussion

Developing the UHI e-module is based on the condition of UHI in Surakarta, Central Java, Indonesia. The expectation of the UHI e-module can be applied to other cities with adapt to the contextual state of that city. This UHI e-module is the development of the Reducing UHI: Summary of Basic UHI Strategies e-module by The Environmental Protection Agency (EPA). The difference in this study is the geospatial-based research approach included in the development of mate-

rials based on the UHI phenomenon in Surakarta and spatial sampling methods. The geospatial approach in this DDR is appropriate to (Jiang & Yao, 2010), who argued that geospatial analysis and modeling, combined with GIS's robust data storage and visualization capabilities. GIS has become an essential tool for understanding urban structure and dynamics where UHI is a phenomenon caused by the urban morphology system. (Musa, Hashim, & Reba, 2017) stated that geospatial tools offer new opportunities for ecosystem management from various geographic information on elements of urban structure and dynamics can be derived from two intertwined factors (physical and socioeconomic). In addition, a spatial analysis approach is used in determining the sample at each DDR phase.

**Need Analysis Phase**

**a.    Sampling and Population of Need Analysis**

In the needs analysis phase, the first step is sampling by multi-stage sampling based on cluster samples, and the third step is sampling by random samples. Samples were collected based on UHI-affected school locations in the Sororaya city area. Multi-stage sampling is a transition from wide to narrow samples using a step-by-step process (Ackoff, 1953). Hierarchical sampling designs typically apply to large geographic areas. Combining different stochastic sampling techniques is the most effective and efficient way to achieve multi-level sampling (Etikan, 2017; Rahi, 2017). With multi-level random sampling, the population is generally very large, or the individual cannot be effectively distinguished, so the test must be selected in two or more steps.

Need analysis phase: Samples were taken through teacher membership in each district's high school geography teachers (Musyawarah Guru Mata Pelajaran Geografi/MGMP). Besides that, the teacher sample is taken by stratified random sampling. The sample was collected based on the school's location affected by UHI in the Soloraya City area. Surakarta City is the capital city of the Soloraya Region in Central Java, Indonesia, which divides the 6 surrounding Surakarta City, namely: Wonogiri District, Sragen District, Klaten District, Sukoharjo District, Boyolali District, and Karanganyar District (Figure 2).
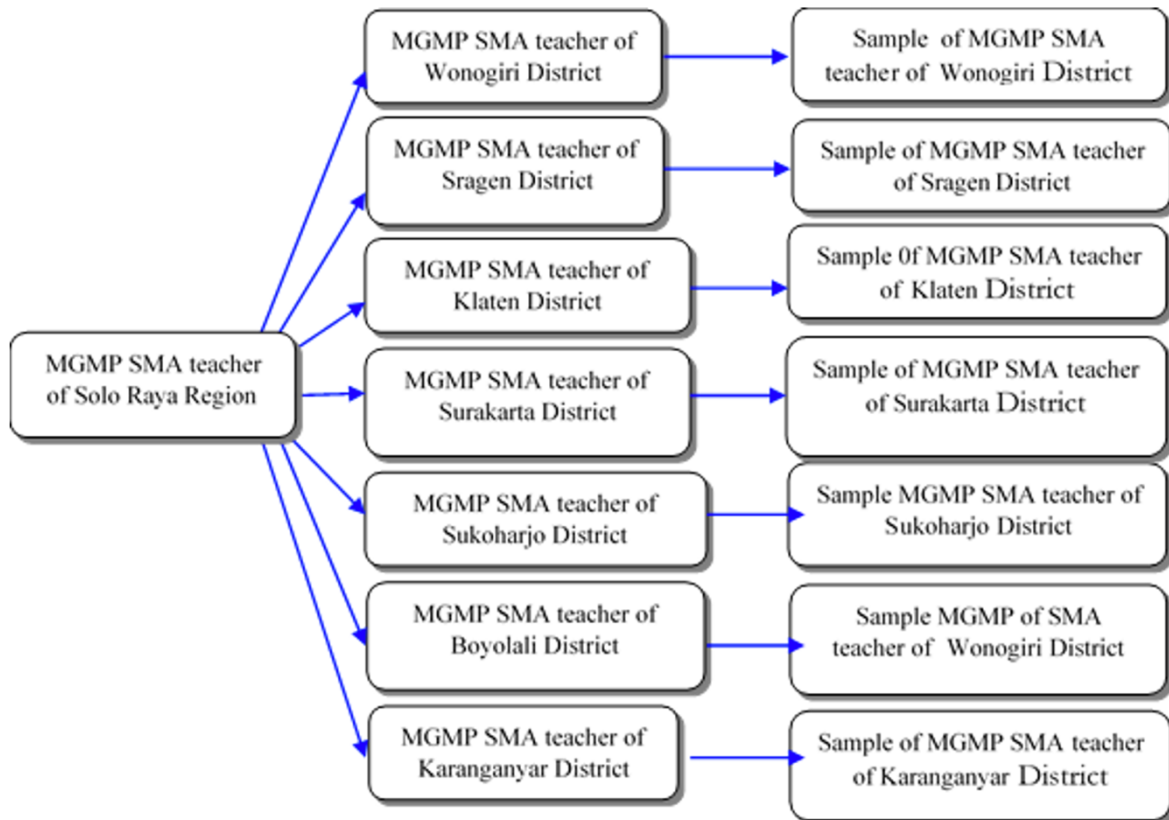
**Figure 4. Teacher Sample of Need Analysis**

The sample is based on the spatial area where the urban heat island phenomenon is indicated by the difference in temperature between the urban and rural areas. Urban heat island (UHI) is a commonly watched phenomenon around the world which is an urban area with significantly higher temperatures than those within the encompassing regions(de Groot-Reichwein et al., 2018; Lee et al., 2020; Wang et al., 2019). Moreover, (Heaviside, Macintyre, & Vardoulakis, 2017) argued that the UHI escalated, for the most part, characterized by the difference in air temperature between built-up urban areas and rural areas) within the urban canopy, the layer is more articulated at night time, when it can reach values of up to 10 °C in large cities. A sampling of teachers based on the distribution of school locations is expected to describe the urban heat island media needs of urban and rural teachers.

**b. Instrument of Need Analysis**

This study uses several instruments in each phase. Instruments were adopted from several previous studies validated by several experts. Need analysis is done through a questionnaire based on literature review and expert endorsement to get content needs analysis and graphic need analysis of the e-module. The questionnaire of contents needs analysis consists of 5 items: respondent school identity, respondents identity, UHI literacy of teachers or students, need's contents, and graphical media of the UHI e-module. A questionnaire on UHI literacy was developed dependent on The OECD's International Program for Student Assessment (PISA) in 1999, which was divided into 3 indicators, namely: (1) Indicators of scientific concepts; (2) Indicators of scientific processes, and; (3) Scientific situation indicators. The

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questionnaire validates by experts in UHI and the development of learning media.

### c. Collecting Data Procedure of Need Analysis

Collecting data on need analysis divides into two stages; firstly, collecting the data of UHI in Surakarta based on imagery interpretation. Secondly, collecting the data need a questionnaire of the UHI e-module. The need analysis data for the UHI e-module was distributed to the teachers in the Surakarta region who were selected as respondents. Documents analysis included the syllabus of SMA (Senior High School), lesson plans, learning activities, and guidelines

### d. Technical Data Analysis of Need Analysis

UHI is measured through NDVI and LST index to get the vegetation density and surface temperature in Surakarta. The NDVI and LSI analysis of the City of Surakarta was conducted on the condition of Surakarta in 2003, 2008, 2015, 2017, and 2019 based on

Landsat 7 ETM + imagery, Surakarta City administration map, and ground checkpoints. Analysis using Envi 4.0 software and statistical analysis and lay-outing using ArcGIS 10.2 software.

### Design and Development Phase
### a. Sampling and Population of Design and Development Phase

Design and Development Phase: The indicators of the UHI e-module are adapted from the hands of "Reducing UHIs: Compendium of Strategies UHI Basics" The United States Environmental Protection Agency, divide: UHI definition, forming of UHI, Urban Geometry, Caring of UHI, Strategies to Reduce UHIs, and Additional Resources. E-module developed based on the EPA's indicator on Reducing UHIs: Compendium of Strategies UHI Basics with modifying considering Senior High School Geography syllabus in Indonesia on global warming competency.

**Table 2. UHI e-Module Develop of The "Reducing UHI: Compendium of Strategies UHI Basic" by EPA**

| EPA indicators on "Reducing UHIs: Compendium of Strategies UHI Basic" | UHI E-module Design |
|---|---|
| What is UHI? | 1. UHI Definition<br>  1.1. surface UHI<br>  1.2. Atmosphere UHI |
| How does UHI Form? | 2. UHI influence factors<br>  2.1. Reduced Vegetation<br>  2.2. Properties of urban Materials<br>  2.3. Anthropogenic Heat<br>  2.4. Additional Factors |
| Why do we need to care about UHI? | 3. UHI impacts<br>  1.1. Energy Consumption<br>  1.2. Air Quality and Greenhouse Gases<br>  1.3. Human Health and Comfort<br>  1.4. Water Quality |
| Strategies to reduce UHI | 4. Strategies to Reduce UHI<br>  1.1. Trees and vegetation<br>  1.2. Green Roofs<br>  1.3. Cool Roofs<br>  1.4. Cool Pavements<br>  1.5. Heat Islands Reduction Activities |

Development uses Borg and Gall model. Experts in UHI and media learning validate adoption or e-module indicators. The indicator of this UHI e-module divides into four indicators, namely: (1) UHI definition, (2) UHI influence factors, (3) UHI impacts, and (4) UHI mitigation (Table 2).

b. **Instrument of Design and Development**

The development phase used the assessment questionnaire from the experts. Experts assess the UHI contents and graphical media aspects of the UHI e-module through document content analysis. Pre-test and post-test questionnaire UHI contains questions about the e-module material based on student collaboration skills. Collaboration or teamwork is expected from researchers, just as being researchers competent good research collaborators need to work with others towards common objectives, for example, project objectives, publishing articles (Tozer & Westoby, 2016).

c. **Collecting Data Procedure of Design and Development**

The design and development stages require the involvement of the UHI expert and learning media expert to validate the Product. The experts evaluate the design based on the checklist to evaluate the instructional material and give their comments for evaluation. Second, when the documents are evaluated by experts and returned, the next stage is to identify and write the comments which require further investigations.

d. **Technical Data Analysis of Design and Development**

The design and development phase uses the Fuzzy Delphi Method, which encourages the experts to assess the UHI e-module. Rejab argued that the FDM is utilized in this study specifically to validate the content rather than other validation phases of instrument development: face validity, construct validity, and criterion validity (Rejab, Azmi, & Chuprat, 2019). FDM is a method of measurement that depends on the modification of the Delphi Method. FDM is certifiably not another approach dependent on a classical Delphi method where the respondents must be from inside the hover of experts who have experience in the context of the study. This improvement indirectly strives to make FDM a progressively compelling measurement approach, whereby FDM can resolve the issue of who has uncertainty for some research issues.

Triangular Fuzzy Number and Defuzzification Process are the elemental components within the examination of FDM. Triangular Fuzzy Number comprises values m1, m2, and m3, where m1 is the smallest value, m2 is the foremost conceivable worth and m3 represents the highest esteem. The three values in this Triangular Fuzzy Number appear in the triangular min chart against the triangular value (Figure 3). Within the Triangular Fuzzy Number stage, two conditions ought to be taken after choosing the acceptance of a component that's inspected by the expert agreement: (1) condition incorporates the limit/threshold value (d) and; (2) besides, the condition is the rate of the expert group for a component. The determination of edge value (d) depends on the predetermined equation.
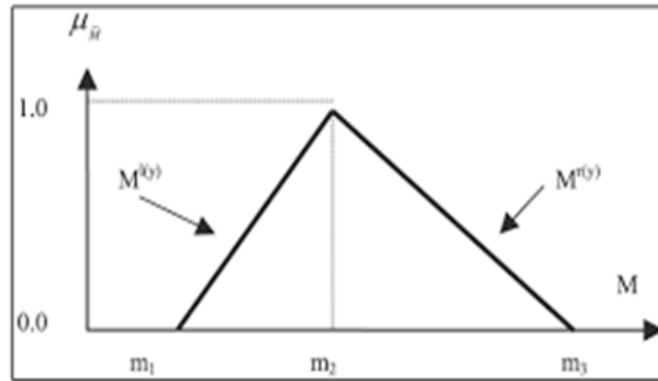
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**Figure 5. Triangle Graph Fuzzy Delphi**

The defuzzification process refers to choosing the positioning of each construct, component, element, issue, variable, and sub-variable found within the investigation. This process aims to empower the analyst/researcher to see the vital factors and sub-enabling requirements. It seeks to choose the ranking and needs of each component being examined. This positioning stage will offer assistance to make information based on the wants dependent on the expert agreement that serves as the research respondent. Defuzzification must get confirmation from the expert group on each component. This condition uses the median value of the median, which should be known as the alpha-cut (-cut) value used. Three equations can be used within the defuzzification process. Researchers can choose any of these three equations to determine the positioning in their studies, specifically: (1) Amax = 1/3 * (a1 + am + a2), (2) Amax = 1/4 * (a1 + 2am + a2), and (3) Amax = 1/6 * (a1 + 4am + a2). The revelations got utilizing the FDM approach, have to be take after a few methods. Consistance to this strategy is an experimental finding.

## Implementation and Evaluation Phase
### a. Sampling and Population of Implementation and Evaluation

The UHI E-module produced in phase II was then implemented and evaluation of the e-module. The implementation and evaluation phase uses a quasi-experiment design where the school sample is tested by stratified random sampling. The implementation and evaluation phase sample are schools chosen based on the core city of Surakarta and the outer of Surakarta city (Figure 4).
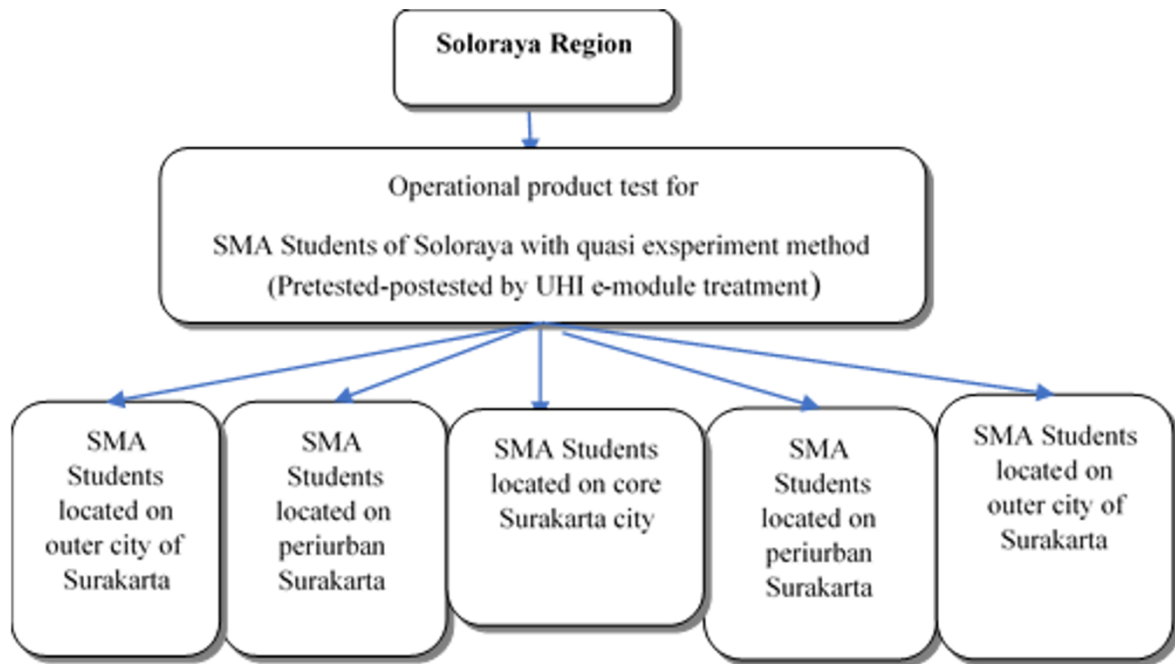
**Figure 6. Student Sample of Implemented and Evaluation**

**b. Instrument of Implementation and Evaluation**

Individual performance goals are content and context-specific (Soylu et al., 2017). Learning Achievement Theory shows how students are motivated to learn, and different types of motivations lead to different results. Learning is influenced by "individual perceptions of their abilities, perspectives on the difficulty of various tasks, and their goals." The student's approach to learning achievement can be explained by two different theories: coping goal theory and achievement goal theory. In addition, Achievement Goal Theory provides a compelling explanation of how student motivation and motivation influence student learning. Achievement goal theory divides learning motivation into two categories. A coping goal approach in which students seek to acquire skills and a (selfish) goal is to compare their performance to other students (Dawe, 2019). The aims of education are a set of educational outcomes achieved by students after implementing educational activities. Teachers expect that students succeed in learning a specific thing. Performance needs to be evaluated or measured (Rahayu, 2018).

**Table 3. The Indicators of Students' Achievement**

| Indicators | Indicators Description |
|---|---|
| What is UHI? | UHI definition: surface UHI and atmosphere UHI |
| How does UHI Form? | UHI influence factors: reduced vegetation, properties of urban material, anthropogenic heat. additional factors |
| Why do we need to care about UHI? | UHI impacts: energy consumption, air quality, greenhouse gases, and human health and comfort<br>water quality |
| Strategies to reduce UHI | Strategies to Reduce UHI: trees and vegetation, green roofs, cool roofs, cool pavements, and heat islands reduction activities |

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Students' achievement of UHI knowledge is calculated based on indicators on the e-module. Pre-test and post-test questions are made based on indicators and validated in the initial field testing stage (Table 3).

Meanwhile, to measure the collaboration of students in this study, it was based on the teamwork instrument by O'neil instrument (Oneil, 2004). The O'neil questionnaire's indicators accordance with the UHI learning e-module, which is participatory learning-based and is done outside the classroom other than in the classroom. The game environment provides a chance to assess critical learning attributes in teams. These incorporate both process and outcome skills for teams. Another form of impact involves the development of social capital among the players. Referring explanation before, this study assumed that collaboration skills could measure with teamwork skills.

O'Neil stated that teamwork track or skills affect how compelling an individual part will be a significant aspect of a group and are domain-independent group skills. Teamwork skills envelop adaptability, coordination, cooperation, and communication.

Effective teams create capability along both tracks. Effective teams have the basic skills required for the assignment and know how to organize their activities, communicate with one another, and respond adequately to changing conditions (Fiore et al., 2017; O'Neil, 1995). Teamwork skills measurement refers to the "Assessment in Team games" developed by O'Neil. The game environment gives a chance to assess the key attributes of team learning. These incorporate both process and outcome skills for teams. Another type of effect involves the improvement of social capital among the players(O'Neil, Chuang, & Chung, 2003). O'Neil divided the team works skills into six categories, namely: (a) adaptability in perceiving issues and reacting appropriately, (b) coordination in arranging team activities to finish a task on time, (c) decision making utilizing available information to make decisions, (d) interpersonal interacting cooperatively with other team members, (e) leadership giving guidance for the team, and (f) communication the general exchange of clear and accurate information. This study uses the questionnaire on the O'Neil collaboration skills (Table 4).

**Table 4. The Indicators of Students' Collaboration**

| Indicators | Indicators Discription |
|---|---|
| Adaptability | perceiving issues and reacting appropriately |
| Coordination | arranging team activities to finish a task on time |
| decision making | utilizing available information to make decisions |
| interpersonal | interacting cooperatively with other team members |
| leadership | giving guidance to the team |
| communication | generally an exchange of clear and accurate information |

### c. Collecting Data Procedure of Implementation and Evaluation

Implementing the UHI e-module requires the involvement of the class teacher in the control class and experiment class in the school, which choosing as a sample. The method of this phase is a quasi-experiment to estimate the causal impact of the UHI e-module on the collaboration skills of school students in Surakarta.

### d. Technical Data Analysis of Implementation and Evaluation

The implementation and evaluation stage uses experimental and quasi-experimental research designs to examine the relationship between the UHI E-module stu-

dents' collaboration skills. Experimental and quasi-experimental research designs determine whether there is a causal relationship between independent and dependent variables. This study uses a Quasi-experimental design in the implementation and development stage. This stage aims to measure the UHI e-module on treatment groups compared to control groups that don't use the UHI e-module on Climate Global competency learning. Using a Quasi-experimental design was based on choosing the samples from the available classes without randomly choosing respondents. It can only use a sample consisting of students without interruption or restructuring the students in the class. In this quasi-experimental study, the pre-post test design of the group (non-equivalent groups pre-post tests design). This design contains two groups of respondents who were not selected randomly. It is difficult to select random samples to represent experiment groups and group control because it cannot change gender, race, achievement, and student position in the classroom (Table 5).

**Table 5. The Pre-test and Post-test Design**

| Groups | Pre-test | Treatment | Post-test |
|---|---|---|---|
| Experiments | $O_1$ | X | $O_2$ |
| Control | $O_2$ | - | $O_2$ |

*Noted:* O = Observation whether pre-test or post-test,
X = UHI E-module treatment,
– = without UHI E-module treatment

Hypothesis testing using t-test and ANOVA. The T-test is used to test the mean score of students 'achievement of pre-post tests in each group, while ANOVA compares students' collaboration skills between the experiment and control group.

## 4. Conclusion

The goodness of design and development research on the e-module of UHI are: 1. the UHI e-module developed from the UHI e-module by EPA "Reducing UHIs: Compendium of Strategies UHI Basic." EPA is one of the pioneering agencies that were become the world's reference to the UHI phenomenon. 2. Based on the Indonesia syllabus of Senior High School, the UHI e-module enriches geography subject in the basic competencies of the atmospheric dynamics on indicators of the impact of global climate change and research on climate and its utilization. The UHI e-module is developed based on the real phenomenon around the students and encourages the students in active learning through collaboration. (3) Development of the UHI e-module based on the DRR approach has stages clearly and orderly. (4) The development of the UHI e-module involves the UHI experts, and learning media resulted in high validation. (5) The development of the UHI e-module based on an effectiveness test and statistical test resulted in an implementation e-module for students. The weakness of this study is: (1) There was not yet teaching-learning material on UHI for school students in Indonesia, which caused the lack of reference; (2) This study should be careful to choose both experts on UHI leaning media experts.

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