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Teachers need analysis: Development of the Urban Heat Island module based on a contextual approach

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Abstract

Since the nineteenth century, scientists have studied the Urban Heat Island (UHI). The negative effects of UHI could be mitigated with the help of interdisciplinary studies, but none have been performed so far. UHI research in schools has some holes that could seriously hinder students' grasp of climate change. The purpose of this research is to ascertain whether or not the Urban Heat Island module is necessary for enhancing students' understanding of climate change in the classroom. The Greater Solo Area Region's 72 geographic teachers were chosen at random for this study. Preliminary data on teachers' familiarity with UHI in the Greater Solo Area shows that, on average, they know very little about UHI. About 47 percent of the teachers surveyed had no understanding at all of UHI, while the remaining 25 percent had a moderate amount of knowledge, seven percent had high understanding, and three percent had very high understanding. Results from a test given to educators in both the suburbs and the city corroborated these observations. All teachers agreed that the UHI enrichment module created using a contextual approach was necessary as a supplementary medium for climate change material, as indicated by the results of the teacher needs assessment tests.

Keywords: Urban Heat Island; module development; climate change; contextual approach

1. Introduction

One-fifteenth of the global urban population resides in South Asian cities. Unfortunately, widespread environmental degradation in these urban centers makes them especially vulnerable to the effects of global warming. The temperature disparity between cities and the rest of the country, or the Urban Heat Island (UHI) effect, is one example (Kotharkar, Ramesh, & Bagade, 2018). Researchers in Indonesia have broadly concentrated on UHI; for example, the UHI recognizable proof in Jakarta and Lampung focused (Manik & Syaukat, 2015). The aftereffects of UHI research in Lampung and Jakarta show that UHI dangers of UHI were distinguished in the two urban areas.

Meanwhile, a study reported that because of the land-use change in Jakarta from 2000-2012, around 49.7% of green open space was changed over into developed regions bringing about an expansion in surface temperature and making the peculiarity of UHI in Jakarta (Rushayati, Prasetyo, Puspaningsih, & Rachmawati, 2016). Furthermore, research indicates

that UHI affects rainfall patterns in Jakarta. Since 1986, the effects of UHI on the increasing trend of extreme rainfall and aerosol in Jakarta have been studied (Syamsudin & Lestari, 2017).

Human activity has resulted in time and space climate change, such as urbanization. Microclimate changes are being caused by urban population concentration. Changes in global climate are something that people everywhere are feeling right now. The phenomenon of climate change is indicated by the increase in temperature caused by increased human activity. Global temperatures are expected to rise by 1.0-3.7°C in the twenty-first century, depending on future greenhouse gas emissions (Abulibdeh, 2021; Anderson, Hawkins, & Jones, 2016; Fawzy, Osman, Doran, & Rooney, 2020). Global warming has pushed more people into urban areas, and a growing population can increase the dangers of living in a hot environment (Heaviside, Macintyre, & Vardoulakis, 2017). The urban heat island (UHI) effect occurs when city temperatures are consistently higher than suburban ones (Lee, Kim, Sung, Ryu, & Jeon, 2019; Masumoto, 2015; Zhou et al., 2018). Understanding future temperature changes in cities necessitates an understanding of the combined effects of urbanization and climate change (Chapman, Watson, Salazar, Thatcher, & McAlpine, 2017; Heaviside et al., 2017). UHI causes thermal discomfort, increases energy consumption, and degrades public health (lowering quality of life) (Aram, Solgi, Garcia, & Mosavi, 2020; Filho et al., 2021; Sen & Khazanovich, 2021).

Researchers have studied urban heat islands in depth for quite some time. In the nineteenth century, people began taking official readings of urban atmosphere for the first time. Since then, hundreds of measurement studies have been done. There is a lot written about the "city temperature effect" or the "heat island effect" in academic journals (Stewart, 2019). South Asian cities with similar urbanization patterns, Geography, and climate create favorable conditions for collaborative multidisciplinary research to discover knowledge related to the thoughtful response and management of the negative effects of Urban Heat Islands (Kotharkar et al., 2018). Bahi, Radoine, and Mastouri (2019) sorted over 3,700 UHI-related articles published in the Web of Science Database between 1989 and 2016 into different scientific fields based on their findings. Meteorology (26%), environmental science (19%), engineering and remote sensing (11%), and building services (10%) had the most published studies, followed by energy and geology. In addition, research was conducted in physics, Geography, and urban structure. Only 5% of all literature was published in urban science journals, even though every article discussed urban systems. This analysis found that over 3,700 journals completely ignored the topic of educational strategies for reducing UHI (Bahi et al., 2019).

Inadequate climate change knowledge has an impact on mitigation and adaptation. In the future, young people are expected to be the most vulnerable to climate change. Adolescents, on the other hand, are excellent change agents in resolving climate change phenomena (Stevenson, Nicholls, & Whitehouse, 2017; Williams, Fenton, & Huq, 2015). It is critical to research young people's knowledge gaps about climate change to engage youth properly. Because of the growing belief that knowledge is crucial for developing a community, adaptability must be measured (Nigatu, 2014). The UHI can be taught in schools using climate change-related materials.

UHI is a climate change phenomenon that has not been taught in schools. In the meantime the, several of Indonesia's largest cities have been under attack from UHI. We looked into resources for teaching about climate change and its effects on students in Indonesia's tenth

grade, keeping in mind the school's geographies requirements. The basic capabilities of atmospheric dynamics material include global warming. UHI, one of the results of climate change, is included as an example of an indicator of climate phenomena in the geographical curriculum of the last ten years of high school. UHI has not been remembered in the course books, so UHI knowledge can be obtained through the UHI e-module following the Education Ministry's Regulation. UHI e-module is a book that contains advanced material of texts in essential and optional schooling. The UHI e-module further develops understudies' reasoning abilities and expands their viewpoints on the climate in light of the most recent information. Aside from a reasonable substance, UHI e-module should be introduced in a magnificent order to cultivate understudies' advantage in perusing. Teaching the UHI phenomenon in schools, especially urban schools, is essential. The effects of UHI threaten urban students. Their learning process can be uncomfortable. As a result, they need to be placed in a structured yet engaging setting that encourages them to be actively involved in their education. A classroom's temperature rises in tandem with the city's when the weather outside gets hot (Puteh, Ahmad, Noh, Adnan, & Ibrahim, 2015). By studying Geography, UHI can educate its students on weather dynamics. Unlike other topics, UHI is not covered in the textbook, so information about UHI can be spread through the UHI module.

The Solo District in Central Java is where the survey was conducted, one of the major cities on the Indonesian island of Java. The regencies of Sukoharjo, Boyolali, Wonogiri, Klaten, Karanganyar, and Sragen surround the Greater Solo Area, which is situated in the lowlands. Surakarta City, situated in the region's center, is the capital of the Greater Solo Area Region. However, Surakarta's rapid growth has resulted in agglomeration (Sugestiadi & Basuki, 2019). In 2015, Surakarta's population density reached 11,530.99 people per square kilometer, increasing the demand for urban space (Putri, Rahayu, & Putri, 2017). Increases in landuse development in Surakarta have been relatively linear, growing by 34% between 1999 and 2017. The temperature change in Surakarta is based on the continuous change of the temperature surface from 21-24°C (lowest) to 34-37°C (highest) in 1994, 2000, and 2017. (Baroroh & Pangi, 2018).

Indicators of climate change phenomena can include UHI because it is one of the effects of global warming. Surakarta's average surface temperature increased from 33.1-35°C in 2003 to 36-37°C in 2011, on the basis of LST analysis of Landsat TM 8 satellite imagery. Increasing UHI threatens the Surakarta community, including school children, as a result of the city's changing microclimate. One of the most at risk demographics, students are also an integral part of the community's educational infrastructure and a generational resource with potential application in disaster and UHI risk reduction. To address these issues, a user need analysis test should precede the development of the UHI e-module tailored to the ° region. Analysis of the needs for developing teaching materials and feasibility analysis are prerequisites for developing teaching materials. Existing issues related to the learning environment, technology, student characteristics, and others precede the analysis (Serevina, Astra, & Sari, 2018). Needs analysis is required for teachers and students as users. White et al. (2016) stated that the perspectives of students and educators/teachers are critical to developing practical and effective programs and supports. This research aims to identify the UHI module based on a contextual approach required by teachers to improve student's knowledge of climate change in the Greater Solo Area Region of Central Java.

2. Method

This study was conducted as part of the first phase of R&D, the need analysis phase. The investigation phase employed both descriptive and quantitative methods. Sugiyono (2013) defines quantitative description as a study that finds the worth of a variable independently of any other variables. There was a random selection of 250 Geography professors from the Greater Solo Area Region. Using the Slovin formula with a margin of error of 10%, we were able to select a group of 72 educators to survey. All Geography teachers were unfamiliar with UHI knowledge. The UHI phenomenon was also left out of climate change education programs at the school level. As a result, The UHI phenomenon was also left out of climate change education programs at the school level. To gauge the extent to which educators in both urban and rural settings understand UHI, a preliminary study was conducted. The independent sample t-test was used for normality and homogeneity in the various tests of teachers' UHI knowledge.

Table 1 displays 72 participants from the Greater Solo Area Geography subject teacher group demographic information. 45.8% of the participants were female, while 54.25% were male. Regarding age, most participants were over 50, accounting for 51.4%, with 50 teachers accounting for 25%. Over eighty-two percent of the participants held bachelor's degrees, and nearly nineteen percent held master's degrees. In contrast, in terms of the number of years they had spent teaching, 55.6% of teachers had a combined experience of more than 20 years., while 29.4% had spent between 16 and 20 years in the classroom.

Online questionnaires were distributed to members of a teacher group specializing in the subject of Geography in the Greater Solo Area. All responses were kept strictly confidential, and participants were given the option to opt out of the study altogether. On April 2021, this research began collecting data. The preliminary study used the UHI knowledge questionnaire, based on results from the 218 PISA test of science comprehension and confirmed by industry professionals. Scientific literacy is defined as a person's understanding of scientific concepts, phenomena, and processes and their ability to apply this knowledge to new and sometimes non-scientific situations (Économiques, 2019). On the other hand, the UHI module requirements test instrument was validated by content experts, which was derived with permission from BSNP (The Indonesian National Education Standards Agency). UHI knowledge parameters by teachers are as follows: 1) understanding the Urban Heat Island information, 2) implementing knowledge of Urban Heat Islands as an example of global climate change in school Geography lessons, 3) understanding the Urban Heat Island, something that alters city temperatures, 4) an understanding of the term "Urban Heat Island" describes a phenomenon in which city temperatures are consistently higher than their rural counterparts, and 5) knowing that there has been an increase in temperature in urban areas recently, affecting people's daily activities.

3. Results and Discussion

This survey's respondents were high school teachers from the Greater Solo Area Region. Surakarta City, Wonogiri Regency, Sragen Regency, Klaten Regency, Sukoharjo Regency, Boyolali Regency, and Karanganyar Regency comprise the Greater Solo Area Region. Surakarta is Central Java's second-largest city. In the meantime, Surakarta is the urban hub of the Greater Solo Area, which is largely rural. Figure 1 shows images of the Greater Solo Area Region which shows the morphological differences between the City of Surakarta and the surrounding area.

Figure 1. Images of the Greater Solo Area Region Show the Morphological Differences Between the City of Surakarta and the Surrounding Area
Source: google map (December 2021)

Figure 2 depicts the respondent's profile. Surprisingly, the age group of 40-50 years and older dominated the age group of teachers, reaching approximately 70%, indicating that the teachers' profile in Soloraya is senior teachers. Furthermore, it is in line with the dominance of teaching experience found in the teaching experience group for 16-21 years. The supremacy of old teachers with long teaching experience should have a wider mastery of Geography material compared to younger teachers and their new teaching experience. Most of the respondents in this study had undergraduate degrees based on their education.

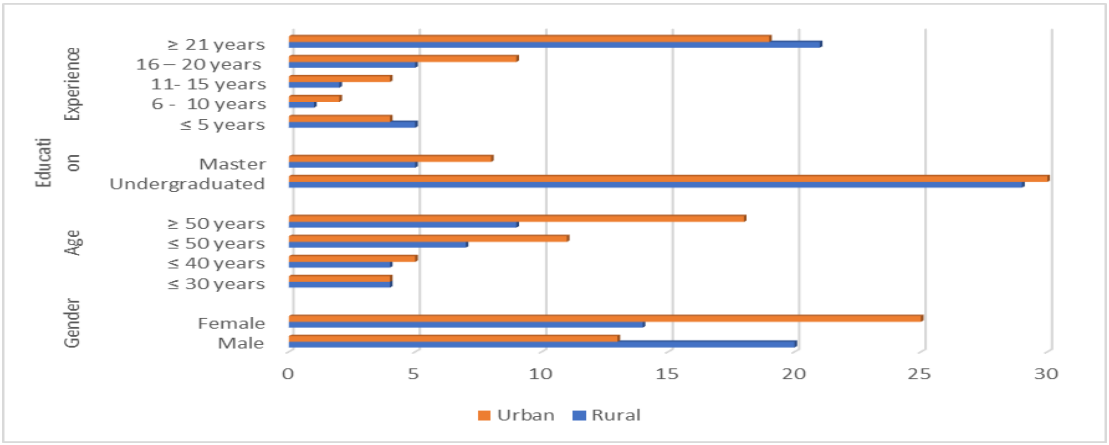

Figure 2. Respondents Profile Graph

According to Susilawati, Anwar, and Khoirunisa (2016), Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) analyses show that the city of Surakarta is at risk of becoming a heat island. From 2003 to 2011, the NDVI in Surakarta was only 0.491. Meanwhile, LST analysis of a Landsat 7 image from 2003 reveals sparse vegetation

(there is so little vegetation that the town overpowers the landscape). In 2010, Surakarta's average surface temperature was between 33.1 and 35 degrees Celsius, while it rose to 36-37°C in 2011. Susilawati found evidence of UHI in Surakarta as far back as 2011, so it's important to find out if people there are aware of it. This research shows that UHI educators in the Greater Solo Area Region have below-average knowledge. There are five levels (very low, low, medium, high, and very high) to describe teachers' levels of UHI knowledge. Figure 3 depicts the outcomes.

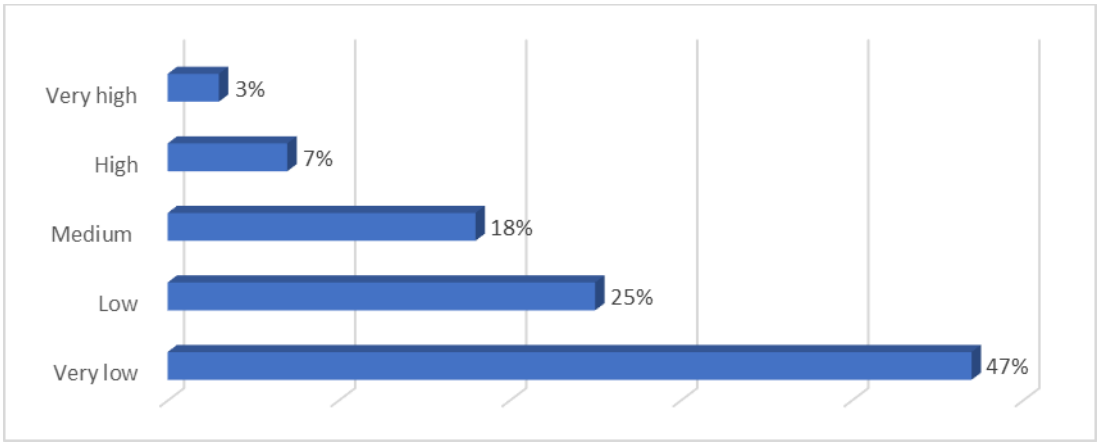

Figure 3. Classification of UHI Knowledge of Teachers in the Greater Solo Area

Generally, UHI's knowledge of the Greater Solo Area teacher is still low. Figure 3 shows that 47% of the participants had very low UHI knowledge, while 25, 18, 7%, and 3% had low, medium, high, and very high knowledge, respectively. Furthermore, with detailed parameters, the teachers' UHI knowledge is illustrated in Figure 4.

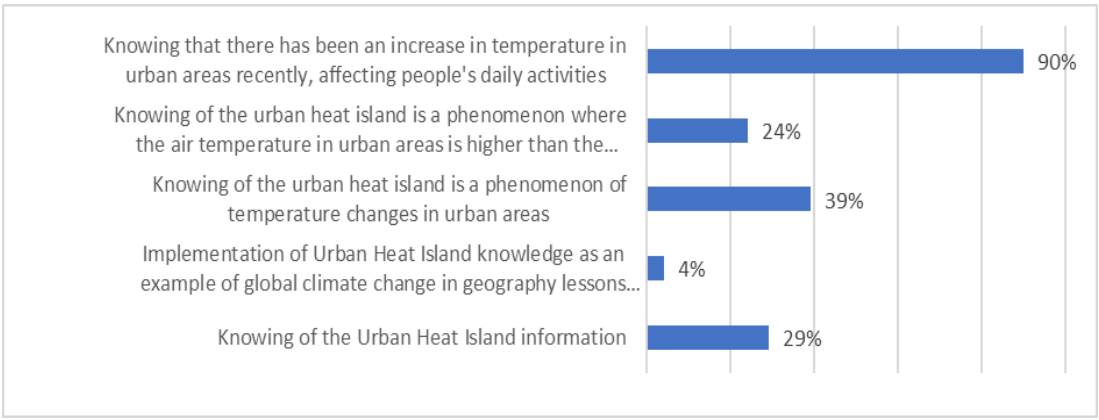

Figure 4. Teacher UHI Knowledge in the Greater Solo Area

Teachers have limited knowledge of UHI information, with only 29% receiving UHI information. Only 4% of polled educators cited UHIs as an example of climate change in the classroom, revealing a significant knowledge gap among the educator population. In addition, 39% of educators know that urban heat island (UHI) is a phenomenon brought on by shifts in urban microclimates. The UHI phenomenon is characterized by higher temperatures in urban areas compared to the surrounding regions, but only 24% of educators are aware of this fact.

In other words, the teacher believes that the recent temperature increase affects everyday life. The following parameter represents UHI's knowledge in the context of the teacher's situation.

Depending on where they live, teachers in the Greater Solo Area are classified as rural or urban. Nonparametric statistics were used in this study, in addition, the One-Sample Kolmogorov-Smirnov test was utilized in order to examine the data for normality. The findings of the normality test indicated a significance value (Sig.) that was lower than 0.005, showing that the study's data did not follow a normal distribution. Table 1 displays the results of a Mann-Whitney test that compared the levels of UHI knowledge held by teachers in rural and urban settings.

Table 1. P-Value of the Mann-Whitney U Test

Statistics on Tests	
	UHI Knowledge
Mann-Whitney U	489.000
Wilcoxon W	1084.000
Z	-1.854
Asymp. Sig. (2-tailed)	.064

a. Variable for Grouping: Living

Table 1 shows a U value of 489 and a W value of 1,084, for a Z value of 1.854. There is no difference in UHI knowledge between urban and rural educators, as indicated by the Sig or P-value of 0.064>0.05. With the help of the Greater Solo Area's Geography teachers, UHI education must be consistently disseminated to students and teachers alike. The UHI enhancement module is a potential medium for expanding Indonesian high school students' understanding of fundamental global climate change. This module can be used in conjunction with global climate change materials. This study's needs analysis focused on the teacher's requirements for module content based on contextual factors. Figure 5 depicts the eight questions that teachers were required to answer in this regard.

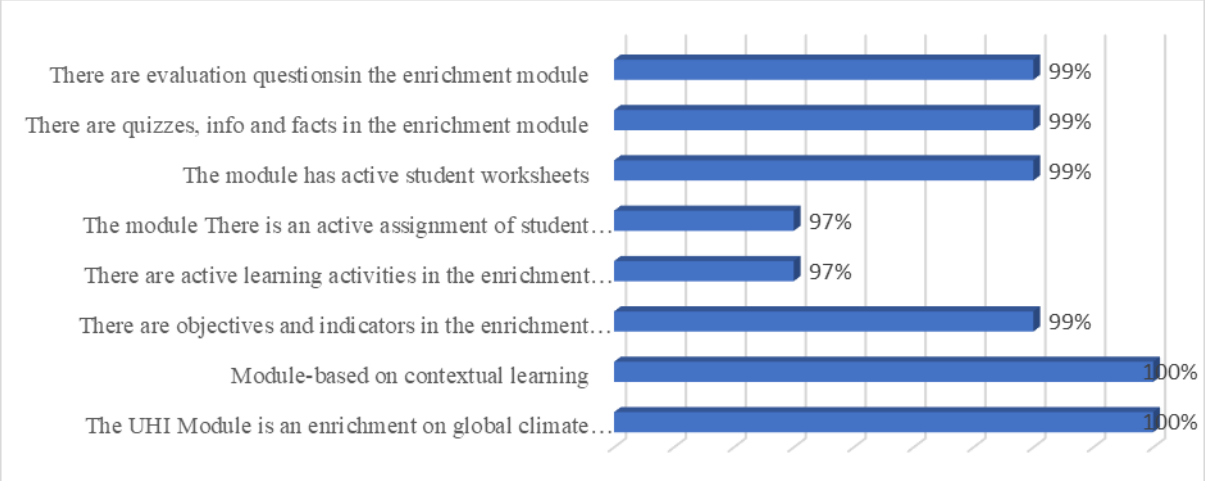

Figure 5. Teacher Need Analysis of UHI Module

As shown in Figure 5, all of the teachers surveyed agreed that the UHI module could be used to supplement the material on global climate change covered in Geography classes. The situation inspired the module's creation. Furthermore, educators generally agreed that this

unit was designed to get students involved in their own education by means of interactive worksheets, quizzes, and current material. The module's learning goals also reflect those found in the standard senior high school Geography curriculum for students in grade ten.

The primary objective of the research was to determine the demand for UHI content modules to improve students' understanding of climate change. UHI as a microclimate change phenomenon affecting the school should be introduced in Geography, mostly climate change. This policy window closely overlaps with the lives of students and teachers, and they might be the ones to define social responses to climate change in the long run. Furthermore, they are the most susceptible to the consequences of past choices (Corner et al., 2015; Stevenson et al., 2017; Sulistyawati, Mulasari, & Sukesi, 2018). Through the presentation of related climate change phenomena, it is possible to lessen the risk that students face from the consequences of climate change. Students are expected to feel more empowered to take action to reduce the effects of climate change as soon as possible after learning about it. Learning about climate change and the environment should be a required part of the curricula of both developing and developed nations. In regards to the environment and the effects of global warming, urban students must understand the rural setting through courses and practical topics, while rural students must understand the urban situation (Demaidi & Al-Sahili, 2021). Creating modules that allow students to learn independently and participate in learning activities is one method for teaching climate change in schools. Because teachers play an important role in this development, a need analysis is required to ensure that the developed module meets the teachers' needs.

Recent changes in the microclimate of the Greater Solo Area indicate the threat of UHI in the region, so students and teachers must be informed. However, according to the survey results, teachers' knowledge of the UHI phenomenon is still limited. The vast majority of educators do not recognize UHI as an urban microclimate phenomenon. As far as academic inquiry goes, UHI falls short, which appears to be the cause of students' and teachers' inadequate UHI knowledge, as there is relatively little UHI-related material at school. Teachers' knowledge of climate change can help students better understand UHI as one of the urban microclimate phenomena. Misconceptions about the consequences and causes of climate change may negatively impact the results of teachers' research on the causes and impacts of climate change, measures to improve the situation, and willingness to act and teach in climate-friendly ways. Climate change is well understood to be anthropogenic. However, according to a previous study, the percentage of teachers willing to postpone climate change is lower than the percentage of teachers who understand climate change (Seroussi, Rothschild, Kurzbaum, Yaffe, & Hemo, 2019). Furthermore, Seroussi et al. (2019) reported that most Israeli teachers believe in climate change and accept human responsibility for it.

Nonetheless, they continue to have many misconceptions and gaps in their understanding of the nature and consequences of climate change, and their willingness to act is low. These results emphasize the importance of better climate change teacher training, highlighting the effects of the phenomenon and possible behavioral strategies in everyday life. Another study found that educators frequently misinform their students about climate change's origins and effects (Liu, Roehrig, Bhattacharya, & Varma, 2015).

In addition to researching how well teachers understand UHI as a phenomenon related to climate change, this research also did a separate test to compare the knowledge of educators

in urban and rural settings. In order to analyze the results of that test, the Mann-Whitney test was carried out. The findings showed that there were no differences that could be considered statistically significant between teachers living in urban and rural areas. As a consequence of this, the hypothesis that urban teachers have a greater knowledge of UHI than rural teachers because urban teachers have personally experienced changes in Surakarta's microclimate was found to be false, due to the fact that the results of the analysis showed no differences between them. This dissimilarity analysis also demonstrated that UHI knowledge is still relatively novel to Geography educators. Teachers in urban and rural areas do not differ in their understanding of UHI. The Greater Solo Area Geography teachers' UHI knowledge is still relatively low, so a UHI knowledge enhancement module is required.

A module is a collection of supplementary materials for classroom instruction. The module is an auxiliary tool for teachers to use in their lesson plans (Ariefiani, Kustono, & Pathmantara, 2016). It provides a structured series of intentionally designed educational opportunities. As a learning tool, it has the following features to aid students in accomplishing their goals: (a) user-friendly, (b) adaptable, (c) self-contained, (d) standalone, and (e) instructional (Daryanto, 2013). The UHI unit was derived from a chapter in the BSNP 2016 assessment textbook that explored how to apply foundational scientific principles in a variety of real-world settings. The majority of educators believe that the UHI curriculum unit could benefit from a more contextualized approach and the incorporation of scientific skills. All of the media in this UHI module can be accessed independently of the rest of the course, making it ideal for independent study. The UHI module includes goals and indicators, active learning activities, operational assignments of student activities, active student worksheets, rating questions and quizzes, and relevant information, as rated by 98% of teachers. Finally, findings from the teacher need analysis demonstrate the fervor with which the UHI module was conceived by educators.

4. Conclusion

Despite the prevalence of urban areas, knowledge about urban heat islands (UHI) is not widely disseminated in educational institutions. The topic of UHI is not covered in the current climate change lessons taught in Indonesia's senior high school Geography classes. However, UHI signs can be seen throughout several cities in Indonesia, including Surakarta. Surveying a high school Geography teacher in the Greater Solo Area about students' awareness of UHI found that few students had heard of the concept. For this situation, the global climate change material should be enhanced by adding the UHI material. Based on our teacher need assessment, all participants agreed on the need to develop the UHI enrichment module using a contextual approach.

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