2023

STEM Education And Research At The University Of Aruba For Sustainable Development Of Small Island Developing States: Case Studies On Energy Efficiency And Waste Management.

Alba DE AGUSTIN CAMACHO
KU Leuven;University of Aruba, alba.deagustin@ua.aw

Mieke DE DROOG
University of Aruba, mieke.de.droog@ua.aw

Wim VAN PETEGEM
KU Leuven, wim.vanpetegem@kuleuven.be

Recommended Citation

De Agustin Camacho, A., De Droog, M., & Van Petegem, W. (2023). STEM Education And Research At The University Of Aruba For Sustainable Development Of Small Island Developing States: Case Studies On Energy Efficiency And Waste Management. European Society for Engineering Education (SEFI). DOI: 10.21427/KW18-8P57

STEM education and research at the University of Aruba for sustainable development of Small Island Developing States: Case studies on energy efficiency and waste management.

(RESEARCH-PRACTICE)

A de Agustin Camacho [1]
KU Leuven; University of Aruba
Leuven, Belgium; Aruba
orcid.org/0000-0002-9358-6439

M de Droog
University of Aruba
Aruba

W Van Petegem
KU Leuven
Leuven, Belgium
orcid.org/0000-0002-4553-4407

Conference Key Areas*: Addressing the challenges of Climate Change and Sustainability & Engagement with Society and Local Communities.*
Keywords*: Engineering education; Education for Sustainable Development; Citizen Science; Sustainability; Small Island Developing States*

[1] *Corresponding Author*
A de Agustin Camacho
alba.deagustin@ua.aw

ABSTRACT

SISSTEM “Sustainable Island Solutions through Science, Technology, Engineering and Mathematics” is a higher educational programme created in 2019 at the University of Aruba in response to the need for engineering education and research in Small Island Developing States (SIDS). In this contribution, the SISSTEM programme is introduced, and how SISSTEM equips engineering students with hard and soft skills while addressing local sustainability challenges is showcased through two case studies.

The first case study presents a bachelor course that combines sustainability theory with a teamwork project in which students conduct an energy audit to a local institution. With this course, students acquire skills to support the energy transition in Aruba. The second case study focuses on the involvement of university students in the creation of a citizen science mobile phone app to tackle waste challenges. This case study presents how students can become agents of change to contribute solving waste management challenges on the island.

Overall, these two case studies showcase how by combining theory and project-based education, students learn to integrate STEM knowledge into multidisciplinary solutions to complex sustainability challenges. In fact, given the cross-cutting nature of sustainability transitions, educating students in integrating the natural environment, technical, social, and economic aspects in engineering solutions is key to increase resilience of islands. As such, at SISSTEM, students acquire hard skills related to their engineering specialisation, as well as soft skills such as integration of disciplines, contextualization, and collaboration.

1 INTRODUCTION

1.1 Small Island Developing States

Small Island Developing States (SIDS) share sustainable development challenges given their remoteness, relatively small size, and fragile environments (Briguglio 1995). In addition, SIDS' vulnerability to external shocks is exacerbated by climate change (de Águeda Corneloup and Mol 2014), making sustainable development imperative to increase resilience in SIDS.

Technological innovation is key for sustainable development and in this regard, engineering education that integrates technology knowledge with principles of sustainable development is essential (Kamp 2006). While engineering education plays a fundamental role for sustainable development, STEM (Science, Technology, Engineering and Mathematics) education opportunities are not always available on SIDS. In this contribution, the higher education STEM programme named SISSTEM (Sustainable Island Solutions through STEM) at the University of Aruba is presented.

1.2 STEM programme at the University of Aruba.

Aruba is a Southern Caribbean island of 180 km² (Derix 2016) with a population of about 112,000 inhabitants (Central Bureau of Statistics Aruba 2020). Until 2019, engineering education was not available on the island, leading to talent drain and creating a dependency on external expertise (Mertens et al. 2023). In response to this need for engineering education and research, the programme SISSTEM was created at the University of Aruba through a collaboration with KU Leuven and with funding from the European Union (Mertens et al. 2022).

SISSTEM consists of a bachelor programme that offers three specialisations (Bio-environmental science; Information and Data Science; Technology and Engineering), a master programme, and 10 PhD research projects (University of Aruba 2023). The principles of education for sustainable development are applied, providing students with state of the art knowledge and equipping them with key skills to solve sustainability challenges (Mertens et al. 2023). In practise, educational material provided by KU Leuven professors is adapted to the SIDS context by academics at the University of Aruba (Mertens et al. 2022), fomenting the local application of STEM knowledge through field trips, practical assignments and educational projects. How local challenges are targeted through education and research is shown through two case studies elaborated in the sections below.

2 TARGETING LOCAL SUSTAINABILITY CHALLENGES THROUGH EDUCATION AND RESEARCH:

2.1 Case study A: Learning while promoting energy efficiency at local institutions.

The SISSTEM bachelor curriculum (University of Aruba 2023) includes the course "Integrative Project" in the 1st academic year with the purpose of teaching the integration of diverse disciplines on sustainability solutions. In this course, students conduct an energy audit of the building of a local institution, with the final goal of

providing sustainability advice. Hosting parties have been the Dutch Marine base located in Aruba, the Queen Beatrix International Airport of Aruba and a local hotel named Amsterdam Manor. During the current academic year, the students are conducting the energy audit at the campus of the University of Aruba, and results are expected to be incorporated into the university's long-term sustainability plans.

"Integrative Project" is a six-month course that combines theory with practical assignments. During the theoretical module, students conduct a literature review on retrofitting techniques, a process during which they are motivated to think critically on the role of contextual factors when retrofitting buildings. Then, the students conduct field work in groups of 3 to 4 students. This consists of four site visits to the hosting institution which acts as a "client". During the first session, the students learn from the "client" the experienced operational challenges and how they expect the students' work to contribute to their sustainability plans. Based on the client's request, the students elaborate a measurement plan for collecting technical data during the second site visit. This includes observations and the use of instruments such as a thermal camera for detecting energy leaks, a lux-meter for identifying the potential use of natural light, and an air quality meter (Figure 1). Additional data required such as energy bills are requested by the students to the institution. During the third site visit, semi-structured interviews with employees from different departments are conducted. This interaction with the energy users is key for students to realise the role of social adoption when implementing technological developments. Based on the collected technical, social, and economic data, students provide to the "client" short- and long-term recommendations for energy efficiency. The results and recommendations are shared through an oral presentation and a written report delivered to the "client" on the fourth site visit (Figure 2).

Figure 1: Student collecting data with a thermal camera during field work.

Figure 2: Students presenting the results and sustainability recommendation to the "client".

Learning outcomes:

The learning outcomes are measured by assessing individual and group assignments. In addition, after course finalisation, students are asked to reflect on the learning experience (University of Aruba 2020).

With this course, students acquire skills to support the energy transition in Aruba. Learning to apply sustainability strategies at local companies has been defined by students as an eye opener – *"This course was something new, working with a client that has a set of requirements was something I have never done. Learning about data presentations, and how to write a proper assessment report was really eye opening.*"

In addition, the collaboration skills obtained by working with peers were also highlighted – *"During the integrative project I have learned to work better in the group and come to terms with compromises. I have also learned that in Aruba there are people/businesses interested in Sustainable Development".*

Overall, this course has proven to equip students with skills necessary for sustainable development – *"I have acquired new skills, I have improved my management skills, acquired knowledge on policy making and learn about recommending"; "I have learned how to work better in a group and how to work in a professional way with organisations. I have also learned how to identify sustainability problems that are not obvious".*

This case study presents how sustainability can be taught as a tangible concept by the inclusion of practical experiences in addition to theoretical lectures. As a lecturer, it is interesting to yearly evaluate and adapt the course content depending on the hosting institution. Other changes are made based on the skill needs by the cohort of students. For example, initially the course only included teamwork assignments, and later, it was decided to include individual assignments as well, for students to develop skills and knowledge both as individuals and as team members.

2.2 Case study B: Involving students in developing a citizen science mobile phone app to tackle waste challenges.

This case study presents the involvement of students in developing a locally applicable citizen science mobile phone app to track post-consumer waste. This was developed by applying a citizen science approach, which increases students' engagement through active and research-based learning (Mitchell et al. 2017).

This project has been executed within the scope of the collaboration between the University of Aruba and KU Leuven which allows for international student exchange both ways. In this case, two software engineering students from KU Leuven showed interest in conducting together their master thesis on building the above-mentioned mobile phone application. While the app development task was assigned to the master students, a multidisciplinary team contributed to the design, including academics from KU Leuven and the University of Aruba. Input from independent software engineers and stakeholders in the field of waste management and citizen science was collected through brainstorming sessions. The app has been developed and tested at the campus of the University of Aruba, providing the opportunity to learn not only for the students developing the app but also for those students testing and evaluating the product.

The research conducted for the app development consisted of a desk research phase followed by an app development and testing phase. First, the students elaborated the research proposal. For that, the students conducted desk research to gain knowledge on the state of the art of citizen science mobile phone apps and on other fields key for

developing this specific technology, such as plastic waste and SIDS' characteristics. In addition, brainstorming sessions involving students and academics, both from KU Leuven and from the University of Aruba, facilitated knowledge transfer across different educational levels and the integration of different points of view.

Next, the two KU Leuven master students conducted an international research stay of two months at the University of Aruba with the goal of developing and testing the app. First, the students focused on understanding the context, this included visiting a local plastic recycling centre which also acts as a collection centre for other waste fractions. In addition, the students sorted the waste disposed at the recyclable bins at the campus, identifying the most consumed products. Additional knowledge on the local applicability of the research was acquired through discussion sessions with expert software developers and an Aruban stakeholder in the field of plastic waste and citizen science.

The app was developed following an agile method. After four weeks, the first prototype was ready to be tested. The test was conducted by university students from different backgrounds during a workshop. A total of three workshops were organised, consisting of a brief introduction to waste followed by 20 minutes during which the students tested the app. Students were assigned random waste items representing the most common disposed products, and were asked to record data on the assigned waste items by using the app. The impressions on the usability and user-friendliness of the app were collected through a questionnaire completed by all workshop participants, a total of 46. While the user friendliness of the app was rated "very easy (to use)" by 69.6% of the participants and "easy" by the remaining 30.4%, the users recommended including additional descriptive features. For example, extra pictures and explanatory text to facilitate waste items classification, especially for the category "other non-recyclables". Of all the respondents, 82.6% agree that the app would help them sort the waste correctly. The motivational factors to use the app were ranked as follows: contributing collecting data (58.7%), reducing university's carbon footprint (45.7%), learning about recycling (39.1%) and getting rewarded for the contribution (15.2%). In addition, 78% of the participants showed interest in creating a log-in profile to follow personal waste recycling patterns. Another recommendation was to add in the app a language selection feature to choose from English, Dutch, Papiamento, and Spanish, the most widely spoken languages in Aruba. This was described as a key aspect for a successful local implementation.

After the testing phase, the thesis students worked on finalising the app (Figure 3). In this round, the students were able to incorporate their own ideas, as well as those provided by users from different backgrounds, providing an opportunity to make the creation process more multidisciplinary. The students concluded their assignment by disseminating the research outcomes to different audiences. This was done by the elaboration of a scientific master thesis manuscript and by the creation of short tutorial videos on how to use the app (Figure 4).

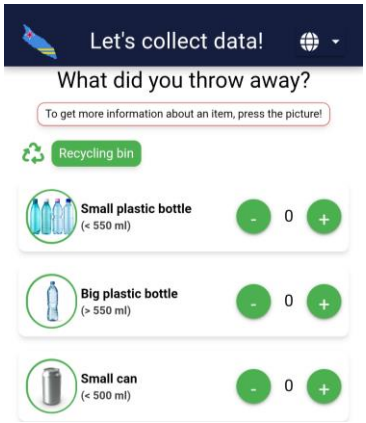

Figure 3: Screenshot from a section of the front-end of the developed app.

Figure 4: Screenshot from the video tutorial.

Learning outcomes:

The learning outcomes were measured by assessing students' skills such as autonomy, team spirit, communication, and critical thinking proven during the process, as well as the scientific rigour in the elaborated scientific manuscript and the oral defence of it. In addition, a semi-structured interview was conducted to students asking them to reflect and elaborate on their acquired skills and competences.

Students conducting an international research stay acknowledged that this experience helped them understand the contextual differences between their home country and Aruba. Technical knowledge on recycling was acquired through the site visit to the Aruban plastic recycling organisation, and a cultural understanding was obtained through interaction with students from the University of Aruba involved in the app testing. "*For cultural standpoint, it is interesting to see how people across the world think about certain issue, and here [Aruba] this is [waste] a really important issue so they really want to contribute"*.

The experiential learning approach applied in this case study, resulted in students learning to work independently. "*We learn from scratch how to do something, how to teach ourselves to do it*". Students believe this learning is an asset for becoming entrepreneurs "*We will work for our own, so for every problem, we will need to search for solutions, our own methods to face those problems*". In addition, the students believed that the setting of this project allowed them to develop a pro-active attitude "*We have to make something, but how we make it was up to us. So, we had the ability to learn things that we were interested in".* When interviewed on their acquired competences, the students highlighted hard skills, such as programming and learning about the architecture of a mobile phone application. Still, according to the students, the biggest learning is on project management, acquired by collaborating with different people. How this multidisciplinary project taught them to communicate with people from different backgrounds was identified as a valuable soft skill: *"For me it is very important for the future to have technical knowledge but to explain this to someone with less technical knowledge in this area, so still in a comprehensive way. I think it is a very important skill".*

The involvement of students from University of Aruba during the development phase supported local students becoming agents of change by participating in creating sustainability solutions. While workshops' participants were not interviewed, from the answers to the survey and open conversations during the workshops, a high interest in this project was perceived. The KU Leuven students giving the workshop quoted "*What I found really nice is that I really sensed that people wanted to change something in Aruba, and they were really motivated to use the app and give feedback to us".* In line with that, the value of making a contextually suitable mobile phone application that could support sustainable development was recognised*: "When we presented the app to them* [the students from University of Aruba]*, they gave a lot of ideas and solutions on how to make it more engaging for people in Aruba specifically. They were also thinking on how this could be good for having a better environment".*

Besides the students' learnings, this case study presents two additional major outcomes. First, it constitutes an example of how sustainability challenges can be targeted through citizen science at higher education institutions, bringing together students and academics from different disciplines. The presented approach can be replicated in future research projects to support sustainability transitions in SIDS, encouraging incorporating inputs from different faculties in the co-creation of locally applicable solutions. Next, the created app is expected to contribute to data collection which could provide insights into institutional waste production (when applied at the University campus) and national waste production (when used at household level). The app could potentially be applicable in other SIDS, constituting a tool for supporting sustainable waste management practices in the region.

3 CONCLUSIONS AND ACKNOWLEDGMENTS

In this contribution, two case studies have shown how education and research considering the specific characteristics of SIDS and the cross-cutting nature of sustainability transitions is applied through the SISSTEM programme. These case studies are not developed in isolation but are linked to SISSTEM bachelor and master theses, and to project-based bachelor courses. In this form, SISSTEM educates students in integrating the natural environment, technical, social, and economic aspects in engineering solutions. In addition to achieving academic goals, these case studies have led to initiatives that make the island more resilient. The Integrative Project course has resulted in numerous partnerships between institutions and the university, facilitating the creation of a locally applicable knowledge network. It has also supported institutions in their energy transition, which creates local examples on how to reduce dependency on fossil fuels. Creating the app tailor-made for the Aruban context provided the possibility of including user's needs and interests, resulting on a locally applicable tool to engage citizens in waste data collection.

The work conducted by students in the described projects is highly appreciated. This research was funded by the European Union (FED/2019/406-549). Its contents are the sole responsibility of KU Leuven and the University of Aruba and do not necessarily reflect the views of the European Union.

REFERENCES

Briguglio, Lino. “Small Island Developing States and Their Economic Vulnerabilities.” *World Development* 23, no. 9 (September 1995): 1615–32. https://doi.org/10.1016/0305-750X(95)00065-K

Central Bureau of Statistics Aruba. “Quarterly Demographic Bulletin 2020.” Accessed July 4rd, 2023. https://acortar.link/UPJTLF.

de Águeda Corneloup, Inés, and Arthur P.J. Mol. “Small Island Developing States and International Climate Change Negotiations: The Power of Moral ‘Leadership.’” *International Environmental Agreements: Politics, Law and Economics* 14, no. 3 (2014): 281–97.https://doi.org/10.1007/s10784-013-9227-0

Derix, Ruud. 2016. “Spatial Developments in the Aruban Landscape: a Multidisciplinary GIS- Oriented approach." *Central Bureau of Statistics Aruba*, Landscape series: 1 (2016). https://www.dcbd.nl/document/spatial-developments-aruban-landscape-multidisciplinary-gis-oriented-approach

Kamp, Linda. “Engineering Education in Sustainable Development at Delft University of Technology.” *Journal of Cleaner Production* 14, no.9 (2006): 928–31. https://doi.org/10.1016/j.jclepro.2005.11.036

Mertens, Anouk, Nadine Buys, Patrick Arens, Georges Gielen, and Eric Mijts. “Capitalizing on Inequalities to Build a Sound Partnership: The Story of SISSTEM an International Collaboration between a Continental and a Small Island State University.” *Higher Education and Society Journal* 34, no. 1 (2022): 527–52. https://doi.org/10.54674/ess.v34i1.525

Mertens, Anouk, Nadine Buys, Patrick Arens, Georges Gielen, and Eric Mijts. “SISSTEM: Sustainable Development on the Small Island State of Aruba.” In *The Bloomsbury Handbook of Sustainability in Higher Education – An Agenda for Transformational Change*, edited by Wendy M. Purcell and Janet Haddock-Fraser. Bloomsbury Publishing, 2023.

Mitchell, Nicola, Maggie Triska, Andrea Liberatore, Linden Ashcroft, Richard Weatherill, and Nancy Longnecker. “Benefits and Challenges of Incorporating Citizen Science into University Education.” *Plos One* 12, no.11 (November, 2017): 1–15. https://doi.org/10.1371/journal.pone.0186285

University of Aruba. "Bachelor of Science in Sustainable Engineering". Accessed May 4, 2023. https://www.ua.aw/sisstem/.

University of Aruba. “Energy Audit of the Dutch Marine Base in Aruba.” Project Report, University of Aruba, 2020.