www.hellenicstem.com
ISSN 2832-840X

Living City project: Integrating Education 4.0 Content and Experiences into the STEAM Classroom

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Abstract
The World Economic Forum's Education 4.0 initiative has identified critical characteristics of high quality learning in the Fourth Industrial Revolution, including content that fosters global citizenship, innovation, creativity, and technology skills, as well as experiences that incorporate, among others, problem-based and student-driven learning. The Living City project for high school students is presented as a demonstration of the integration of Education 4.0 characteristics into the STEAM classroom in a design-centered fashion that allows for student choice and creativity and considers the United Nations Sustainable Development Goals.

Keywords
fourth industrial revolution, education 4.0, sustainable development goals, sustainable cities and communities, computer-aided design, STEAM, high school

◆ Received 21 April 2021 ◆ Revised 26 February 2022 ◆ Accepted 28 October 2022

Introduction
The first three industrial revolutions were based on steam power to mechanize production, electricity to achieve massive production, and computers to automate the production process, respectively. Advancements in, indicatively, artificial intelligence, the Internet of Things, and nanotechnology, have initiated the cyber-physical Fourth Industrial Revolution. As Schwab (2016) argues, *"We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before"*. Apart from the opportunities for a better quality of life the Fourth Industrial Revolution brings, this disruption will be challenging for societies. Hawksworth et al. (2018) analyzed OECD data regarding the tasks involved in the jobs of over 200,000 workers across 29 countries (27 from the OECD) to estimate that 30% of jobs and 44% of workers with low education are at risk of automation by mid-2030s.

Equipping students with knowledge and skills that will be essential for the cyber-physical near future is necessary for them to thrive in this uncharted environment., with a relevant initiative being the Education 4.0 Framework (World Economic Forum, 2020a). The Education 4.0 framework identifies an urgent need to update primary and secondary education school systems to deliver on children's future needs in context of the Fourth Industrial Revolution: "*This transformation calls for shifts in learning content to include both the technical and human-centric skills needed to build growing and inclusive economies and societies and shifts in learning experiences that more closely mirror the future of work*.". Eight critical characteristics of high-quality learning in the Fourth Industrial Revolution are identified in the same report, categorized as "Content" and "Experiences". Content consists of a) global citizenship skills, b) innovation and creativity skills, c) technology skills, and d) interpersonal skills, while Experiences consist of a) personalized and self-paced learning, b) accessible and inclusive learning, c) problem-based and collaborative learning, and d) lifelong and student-driven learning (**Table 1**).

Table 1. The key characteristics of the Education 4.0 framework (World Economic Forum, 2020a).

Education 4.0 Content	Education 4.0 Experiences
Global citizenship skills	Personalized and self-paced learning
Innovation and creativity skills	Accessible and inclusive learning
Technology skills	Problem-based and collaborative learning
Interpersonal skills	Lifelong and student-driven learning

STEM/STEAM education is (naturally) found relevant and important in the context of the Fourth Industrial Revolution (Kamsi et al., 2019; Shatunova et al., 2019; Idin, 2018). This article demonstrates the integration of most of the Education 4.0 characteristics into a five-week project (the Living City project) as part of the American Community Schools of Athens STEAM course. This project-based course is offered for high school technology credits since 2018 and has been designed and delivered to contribute into preparing secondary education students for the Fourth Industrial Revolution (Karampelas, 2021). The STEAM course is designed-centered to promote, among others, the purposeful use of imagination and creativity for problem-solving through Computer-Aided Design (CAD) and the Design Thinking methodology (the "A" in STEAM). At the same time, it has been designed as a student-centered and blended-learning course that encourages and facilitates the student voice and choice.

Even though the Education 4.0 characteristics can serve as guidelines for the transformation of entire educational systems at the national level, their integration is possible at lower scale as well. This article demonstrates such an integration at the sub-course, sub-school year level. The instructional designs and deliveries of, as well as the discussions about the Living City project that are included in this article refer to a period of three years (2018-2021). The student data that are discussed, listed, and visualized have been obtained during the 2020-2021 school year

http://doi.org/10.51724/hjstemed.v2i1.16

and refer to questionnaire responses of 69 international students – most of them from the 9th grade. The following sections consist of the description of the Living City project, the corresponding integration of Education 4.0 characteristics, and the subsequent discussion and concluding remarks.

Project structure and description

The goal of this five-week project is the design of a 3D city that models sustainability. The project's phases are listed in **Table 2**, together with the corresponding student performance indicators. Initially ("Urban Design" phase), students are asked to design an urban area consisting of 15-20 residential buildings and landscape elements (e.g., soil, water bodies). The recommended free online software is SketchUp, still the students can use any software that enables them to design a 3D city. **Figure 1** illustrates the distribution of students' choice of software for the 2020-21 school year. Typically, about half the students choose Minecraft to design their city in as they are confident users of this software already, while the rest use the recommended software, with a few students selecting another tool like SIMS, Blender, or Fusion 360. Then, students are instructed to make their design more realistic by adding buildings and facilities of public interest from a list (e.g., hospital, stadium, school, hotel, restaurant, airport, harbor), naming the city, and estimating its population ("The City" phase).

Table 2. Outline of the Living City project in terms of its different phases in chronological order and the corresponding performance indicators.

Project phase	Performance Indicators
Urban Design	Design residential buildings and landscape elements
The City	Design non-residential buildings and facilities
The Living City	Understand SDG 11-related data and graphs Modify the design to simulate sustainability per the SDG 11
Fine-tuning	Provide peers with constructive feedback Use peers' and teacher's feedback to improve and finalize the design
Presentation and reflection	Present the Living City Reflect on the project

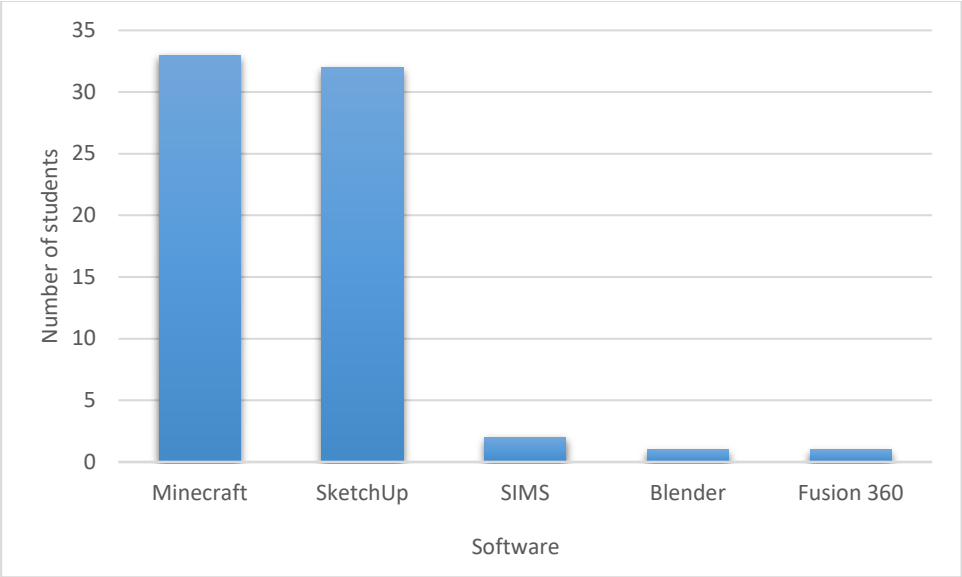

Figure 1. The software used by students to design their city in.

To give students a sense of purpose regarding their city, as well as to make them aware about global issues, students are introduced to the Sustainable Development Goals (United Nations, 2015), with a focus on SDG 11: Sustainable Cities and Communities. Urbanization and corresponding implications are discussed in a data-driven fashion through the understanding of relevant graphs illustrating, indicatively, historical and projected data of urban population per geographical region, countries' income levels, and city sizes (United Nations, 2018), and the mean level of fine particulate matter per geographical region. After a discussion on the specific targets of SDG 11 and examples of how they could be achieved, students brainstorm, state, classify per SDG 11 target, and design three interventions on their 3D city that would simulate sustainability in alignment with SDG 11 ("The Living City" phase). Students are required to brainstorm design interventions that fall under different SDG 11 targets. The 2020-21 school year's distribution of selected targets is shown in **Figure 2**. Indicative student ideas include recycling centers, fire stations, nature reservation centers, underground bunkers, parks, museums, archaeological sites, solar panels on buildings' roofs, and wind turbines. Targets 11.A-C (strong national and regional development planning; implement policies for inclusion, resource efficiency and disaster risk reduction; support least developed countries in sustainable and resilient building) are excluded from the selection process as challenging to visualize in 3D.

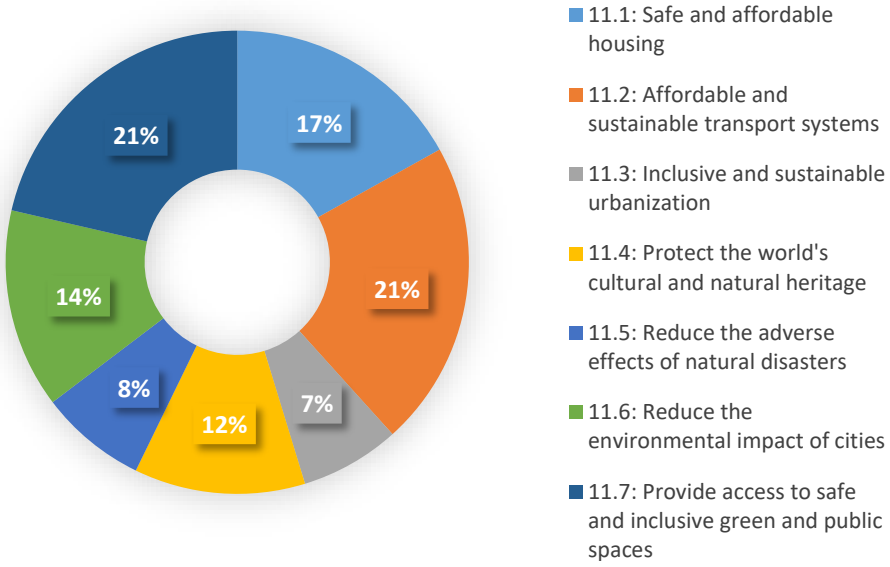

Figure 2. Student choice of SDG 11 targets 11.1-7 to integrate into their design. Numbers may not add up to 100% due to rounding.

Having prototyped their designs, students give each other feedback to improve their cities, as well as they are receiving feedback from the teacher. Peer to peer feedback is facilitated through collaborations in small groups where students share screenshots of their prototypes and document their warm feedback about each other's designs as well as their suggestions for improvement. Students are then instructed to implement any modifications of their designs they deem suitable based on the feedback received, as well as based on their own independent views. Upon completion, students are required to create a video presentation of their final "Living" city. The presentation needs to include a visual and oral tour inside the city that effectively demonstrates a creative, realistic, aesthetically pleasing, and balanced design with the appropriate descriptions of buildings, landscapes, functionalities, purposes, and SDG 11 interventions. Finally, students reflect on the project in terms of perceived accomplishments, challenges faced, and lessons learned. A sample of students' reflection quotes can be found in **Table 3**. Indicative screenshots of students' 3D designs are included in the Appendix (**Figures A1-A4**).

Table 3. A characteristic sample of student reflection quotes regarding the Living City project.

Students' reflection quotes
"I enjoyed the entire process because we were free to use our creativity and talents. I learned a lot about design as well as the sustainable development goals."
"I think the fact that we had guidelines but still full creative freedom was really nice. I enjoyed being able to make decisions about my city independently."
"Well I've been playing minecraft for almost 5-6 years now, and creating a project in the game that I love so much was really great."
"I enjoyed being able to capture my imagination and being able to see it come alive."
"I learned how to make insightful choices considering the SDG factors."
"I can use my imagination to design my own city, that's the most enjoyed part of this project."
"I really enjoyed designing and I am considering following an engineering career after doing this project."

Integration of Education 4.0 content and experiences

The following paragraphs outline the Education 4.0 framework's characteristics categorized as content and experiences (World Economic Forum, 2020a) and discuss their integration into the Living City project. Two of the experiences ("accessible and inclusive learning" and "lifelong and student-driven learning") are not discussed because of their long-scale nature, even though a few of their elements are included in the Living City project.

Global citizenship skills

Despite enabling an inter-connected world of growth and opportunity, globalization and technology might link to pushing planetary boundaries, income inequality, and overall unfairness. It is therefore critical for primary and secondary education students to develop awareness about global issues and realize everyone's importance into acting toward a better future for all. In a report by Deloitte (2019) about success in the Fourth Industrial Revolution, 2,000 executives across 19 countries ranked societal impact as the most important factor to evaluate their annual performance. In the Living City project, students become aware of the global nature of urbanization and its specifics and impact through the understanding of real-data graphs and the specific targets of SDG 11. Moreover, they realize that the need for sustainable cities and communities is only one of several United Nations goals in the context of the SDGs, they design solutions and interventions under a sustainability lens, and inform other students' effort toward sustainability through peer-to-peer feedback. The goal is not for the students to just design a beautiful 3D city (albeit desirable), but to enrich the design process with a sustainability purpose and a global sense of belonging.

Innovation and creativity skills

It is only natural for an industrial revolution to be driven by technological breakthroughs, bringing innovation into the spotlight, together with accompanying skills of, indicatively,

creativity, originality, critical thinking, complex problem-solving, and technology. All these skills score very high in the top 15 skills for 2025 by the World Economic Forum (2020b) in the context of the Fourth Industrial Revolution. In the Living City project, the students tap into their curiosity and imagination to generate ideas, create solutions, and learn through trial and error in the playful environment provided by CAD software like Minecraft and SketchUp. They design buildings, facilities, and landscapes with considerable creative freedom, and add value to their city by implementing modifications to simulate sustainability. The teacher acting as a facilitator instead of a lecturer who is the only source of knowledge also creates room for innovation and creativity in the classroom. Peer to peer feedback between international students of diverse backgrounds is also conducive of innovation and creativity and could be an advantageous point for international school in this sense. It is worth noted that the entire STEAM course is design-centered to promote, among others, creative thinking (Karampelas, 2021).

Technology skills

Technology skills are essential for the future. In the Living City project, students use CAD software to shape their ideas into a digital product. To be successful, they need to understand the interface and the functionalities of the software in use and train themselves quickly to the level where they can satisfactorily design what they intent to. Apart from the technical aspect of technology skills, students realize the importance of designing solutions with the help of computers for a greater purpose like creating a sustainable city. Additionally, they understand that a digital design can be modified and improved at will before implementation, thus highlighting the efficiency aspect of technology. Finally, the students use technology to communicate their work to their peers and their teacher through creating a video presentation by using online or offline screen recording software.

Interpersonal skills

"*As technology continues to automate routine tasks, human-centric skills will provide a distinct advantage over machines in the workplace.*" (World Economic Forum 2020a). Leadership, emotional intelligence, and social awareness, among other interpersonal skills, are expected to be significant in the cyber-physical landscape of the Fourth Industrial Revolution. In the Living City project, students work in groups to provide each other feedback to improve their designs. Empathetical, kind, and constructive feedback is strongly encouraged. A few examples of student feedback that represent effort toward enhanced interpersonal skills are the following: "*I can see how much effort you put and I love the detail.*", "*I like the dark aesthetic of the city and the contrast of black and blue. It has a futuristic look. I like how everything is laid out.*", "*One thing I suggest is that maybe you can add some windows to certain buildings, but it all depends on your choice.*", "*To improve, I would say adding more detail to the residential buildings such as windows to take it to the next level*". When reflecting, most of the students reported enjoyment in watching other students' screenshots of their cities during the peer-to-peer feedback session. More specifically, on a scale of 1 to 5, 36% of the 69 students of the 2020-21 class scored their enjoyment with a "4", and 46% with a "5" (highest level of enjoyment). Additionally, 77% of the students reported that they modified their designs according to other students' feedback. The incorporation of a Sustainable Development Goal into the project also empowered students to consider different points of view and empathize with global issues to then work toward inclusive solutions. Finally, the requirement for a video presentation could also enhance interpersonal skills, as the students prepared videos to explain their designs, the need for sustainability, and the actions taken, to the entire class, with all but one student (99%) reporting enjoyment in watching the other students' video presentations.

Personalized and self-paced learning

The Fourth Industrial Revolution promises personalized industrial products, while technology in general allows for users' choice. Education is not an exception since artificial intelligence, a key technology of the Fourth Industrial Revolution, can enable the creation of personalized learning paths (OECD, 2020). Student voice and choice are of utmost importance in the Living City project. Even though the process is guided, the students can make or are asked to make many important decisions on their own, including the choice of the design software (**Figure 1**), how to approach and design the required buildings, facilities, and landscapes, what SDG 11 targets to focus on to model sustainability (**Figure 2**) and what design modifications to complete in this direction, what feedback from their peers to consider for implementation, and how to present their city through video. The many choices lead to a diversity of final products – designs **(Figures A1-A4)** and video presentations – and, together with the playfulness of the design software used, could justify the students' engagement with the project and the frequently enormous effort put beyond expectations. Several students also reported (in writing during the reflection session and/or orally during class) searching for and using online tutorials to overcome challenges related to designing complex shapes, which is evidence of self-paced and student-driven learning. The project-based nature of the STEAM course (Karampelas 2020; 2021), as well as the purposeful school-wide implementation of blended learning (Avgerinou & Gialamas, 2016; Sidiropoulou et al., 2021), could have created optimal conditions for personalized and self-paced learning as well.

Problem-based and collaborative learning

Transitioning from process-based to problem-based learning could benefit primary and secondary education students as they prepare for innovation-driven economies. In the Living City project, students empathize with real-world challenges like the ones relevant to SDG 11, realize and plan to address these challenges, ideate solutions, prototype designs, and iterate to fine-tune their 3D cities through feedback, following the Design Thinking methodology (Szczepanska, 2019; Chung, 2020; Kolko, 2020; Karampelas 2021). The open-ended nature of the project allows for multiple solutions for the same problem in contrast to unrealistic single-answer learning scenarios, as well as for students to take ownership of their learning. Small group peer to peer feedback collaborations promote team-working, yet the presented Living City project has not been delivered with extensive collaborations in mind, partly because of the CAD software limitations regarding the simultaneous use of the same digital space by many students.

Discussion and concluding remarks

Industrial revolutions are disruptive. Therefore, novel and purposeful educational approaches and practices are required for a successful navigation through the promising yet challenging future of opportunity. The World Economic Forum's Education 4.0 framework is a purposeful initiative to address and harness the Fourth Industrial Revolution and it could become a significant transformative tool for educational institutions, together with the consideration of other, skill-rich frameworks like the 21st Century skills. Essentially, any student-centered and problem-based learning experience that requires the use of technology to design a solution for a global issue might fit into the Education 4.0 framework. Integrated STEM projects and learning experiences in general are suitable by design, as well as because of the connections with the scientific, technological, and engineering breakthroughs and big data solutions that drive the Fourth Industrial Revolution. Moreover, STEAM projects could meaningfully adjust to the Education 4.0 guidelines, because of the opportunities for curiosity, imagination, creativity, and innovation they provide students with. In fact, the framework's key characteristics are inclusive of non-STEM implementations as well, or of further integrations between STEM and non-STEM fields.

This article demonstrated that the integration of Education 4.0 content and experiences in the STEAM classroom is possible. The implementation refers to the small scale in the context of a course's unit for a duration of five weeks and is therefore not a case study of entire educational systems' transformation. Nevertheless, and because of the slow speed the educational systems respond to external change and adapt innovation, it is encouraging to realize that bottom-up considerations of the Fourth Industrial Revolution are possible, especially when they are accompanied by student choice, creativity, and satisfaction. The Living City project could be enhanced further through, indicatively, 3D printing or otherwise physically building the city designs, using microcontrollers and Internet of Things automations to simulate sustainability, research about the science of the fine particulate matter pollutants, and explore, visualize, and analyze SDG 11-related data. As the possibilities for the STEAM classroom (and beyond) are countless, considering the Education 4.0 guidelines, aligning with the United Nations Sustainable Development Goals, and staying informed about the Fourth Industrial Revolution, could meaningfully and holistically enrich the educator's toolkit and impact.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Avgerinou, M. D., & Gialamas, S. P. (2016). The i2Flex Methodology: Definition, Praxis, and Conditions for Success. In *Revolutionizing K-12 Blended learning through the i2Flex Classroom Model* (pp. 135–159). IGI Global. https://doi.org/10.4018/978-1-5225-0267-8.ch010

Chung, V. (2020). Start with design. *Stanford d.School*. https://dschool.stanford.edu/resources/get-started-with-design

Deloitte (2019). Success personified in the Fourth Industrial Revolution. Four leadership personas for an era of change and uncertainty

Hawksworth, J., Berriman, R., & Goel, S. (2018). *Will robots really steal our jobs? An international analysis of the potential long-term impact of automation*. PricewaterhouseCooper, London.

Idin, S. (2018). An overview of STEM Education and Industry 4.0. *Research Highlights in STEM Education* (pp. 194-208). International Society for Research in Education and Science.

Kamsi, N. S., Firdaus, R. B. R., Razak, F. D. A., & Siregar, M. R., (2019). Realizing Industry 4.0 through STEM education: But why STEM is not preferred? *IOP Conference Series: Materials Science and Engineering* (Volume 506).

Karampelas, A. (2020). Developing and delivering a high school Artificial Intelligence course in blended and online learning environments. In *European Distance and E-Learning Network (EDEN)* Proceedings, European Distance and E-Learning Network (pp. 255-261). Academic Press.

Karampelas, A. (2021). Building a design-centered STEAM course. In Avgerinou, M.D., & Pelonis, P. (Eds.), *Handbook of research on K-12 blended and virtual learning through the i²Flex classroom model*. IGI Global.

Kolko, J. (2020). Design Thinking Comes of Age. *Harvard Business Review*. https://hbr.org/2015/09/design-thinking-comes-of-age

OECD (2020). Trustworthy artificial intelligence (AI) in education: promises and challenges.

Schwab, S. (2016). The Fourth Industrial Revolution: what it means and how to respond. https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

Shatunova, O., Anisimova, T., Fairuza, S., & Kalimullina, O. (2019). STEAM as an innovative educational technology. *Journal of Social Studies Education Research*, 10 (2), 131-144.

Sidiropoulou, M., Bakoyiannis, C., & Karampelas, A. (2021). Middle and High School Implementations of Moodle-Facilitated Blended Instructional Designs. In M. D. Avgerinou & P. Pelonis (Eds.), *Handbook of research on K-12 blended and virtual learning through the i2Flex classroom model*. IGI Global.

Szczepanska, J. (2019). Design thinking origin story plus some of the people who made it all happen. *Medium*. https://medium.com/@szczpanks/design-thinking-where-it-came-from-andthe-type-of-people-who-made-it-all-happen-dc3a05411e53

United Nations (2015). Transforming our world: The 2030 agenda for sustainable development. https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

United Nations (2018). World Urbanization Prospects. The 2018 Revision. ST/ESA/SER.A/420

World Economic Forum (2020a). *Schools of the Future: Defining New Models of Education for the Fourth Industrial Revolution.*

World Economic Forum (2020b). *Future of job survey.*

Appendix

This Appendix contains a sample of student "Living City" designs. More specifically, it includes four indicative screenshots of city designs in three different software: SketchUp (**Figures A1-2**), Minecraft (**Figure A3**), and SIMS (**Figure A4**).

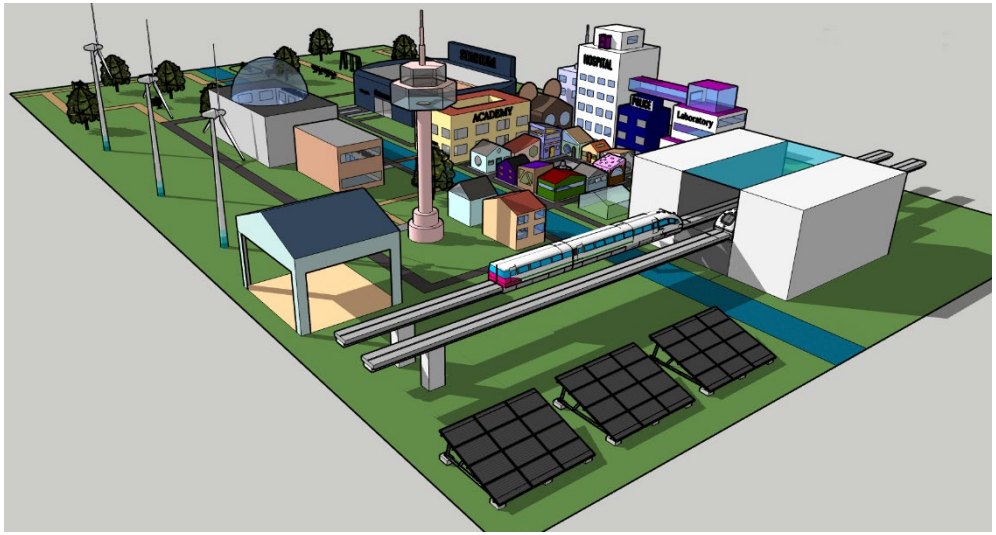

Figure A1. Screenshot of a student's city designed in SketchUp.

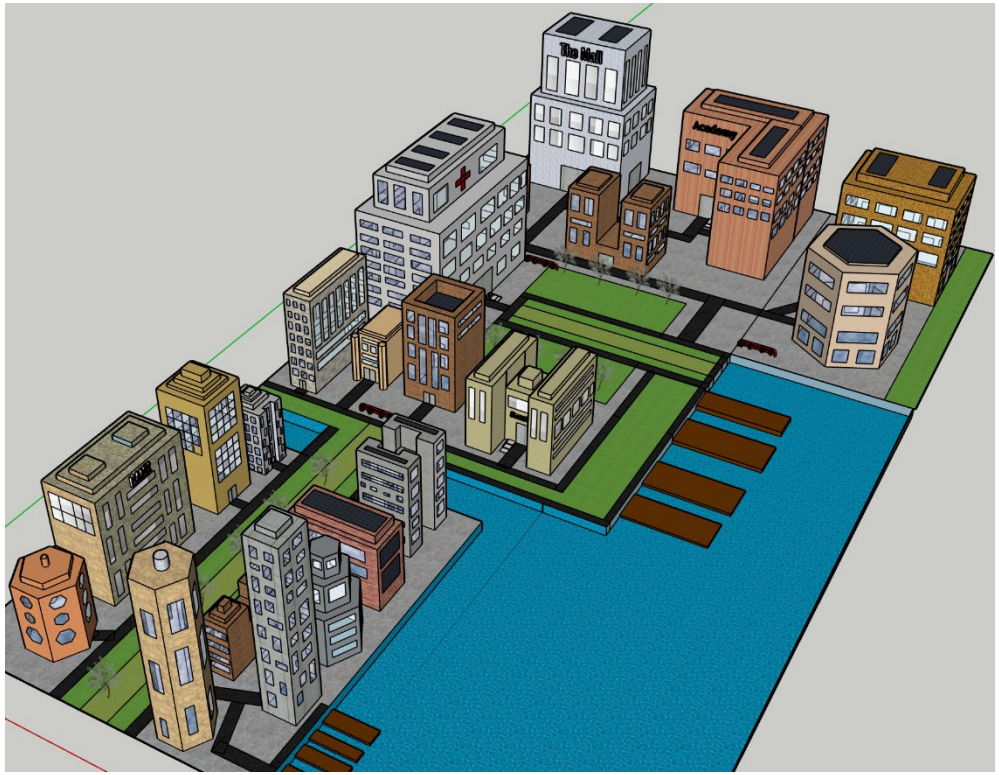

Figure A2. Screenshot of a student's city designed in SketchUp.

Figure A3. Screenshot of a student's city designed in Minecraft.

Figure A4. Screenshot of a student's city designed in SIMS.