United Nations
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for Africa

THE MINISTRY OF EDUCATION OF THE REPUBLIC OF RWANDA

AFRICAN STEAM CENTER OF EXCELLENCE (ASTEAM CoE)

Strategic Document

December/2022

Executive Summary

According to the National STEAM School Education Strategy (NSSES) document of Rwanda, The Rwanda Vision 2050 is about ensuring high standards of living for all Rwandans focusing on areas such as: quality of life; modern infrastructure and livelihoods; and transformation for prosperity. To meet those targets, it is essential to achieve the highest possible quality of education to enable all citizens of Rwanda to build the advanced country that is envisioned to achieve.

It is vital therefore to ensure that the quality of STEAM Education is designed to prepare graduates of the education system with the skills and competencies they need to support Rwanda's vision. The mission of the Ministry of Education (MINEDUC) is to transform the Rwandan citizen into skilled human capital for the socio-economic development of the country by ensuring equitable access to quality education focusing on combating illiteracy, promotion of science and technology, critical thinking, and positive values. It is with these notions that the establishment of innovation and STEAM center is mandatory in Rwanda which could serve the whole citizens of Africa.

This strategic document is prepared with the notion to establish state of the art STEAM Center of Excellence in Rwanda with the support of UNECA. The strategic document enumerates: The anticipated mission, vision, Objectives, rational and expected outcomes of the African STEAM Center of Excellence (ASTEAM CoE). The proposed working pillars of the center, the core and fundamental engagement areas, the labs, the organizational structure, the office facilities and human resource needed to run center are also stipulated in the document. Proposed office and laboratory facilities, different partnership and collaboration schemes, the short- and long-term plans of the STEAM center, the evaluation and monitoring systems of the STEAM programs and the overall estimated cost to establish the center are also some of the main ingredients which are emphasized in this strategic document.

List of Acronyms

ASTEAM CoE	African Science, Technology, Engineering, Arts and Mathematics Centre of Excellence
AISTEAM CoE	African Innovation Science, Technology, Engineering, Arts and Mathematics Centre of Excellence
CBC	Competence Based Curriculum
CESA	Continental Education Strategy for Africa
MINEDUC	Ministry of Education
NSSES	National STEM School Education Strategy
REB	Rwanda Basic education Board
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific, and Cultural Organization

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1. Preamble

The Africa Regional Science, Technology and Innovation Forum 2022 was held from 1st to 2nd March 2022, organized by UNECA and hosted by the Government of Rwanda through the Ministry of Education. The Forum was preceded by the virtual Youth Innovation Bootcamp and a physical bootcamp that ran parallel to the Science, Technology and Innovation (STI) Forum. One of the Outcomes from the Forum was a commitment from the UNECA to support the establishment of a Centre of Excellence in Foundational Skills in STEM Basic Education in Kigali. The Honorable Minister of Education holds the position of chair of the Regional STI Forum until the next Forum which will be held in March 2023 and the Centre should be established before this time.

In Sub-Saharan Africa 70 per cent of the population is under the age of 30, but only seven per cent of Africans enroll in tertiary education. Tertiary education is essential. However, the continent faces a number of challenges that must be addressed if it is to truly educate and empower the next generation of science, technology, engineering, arts and mathematics (STEAM) leaders.

The promotion of STEAM education aligns with the worldwide trend of equipping students for the rapid economic, scientific and technological developments, as well as the changes and challenges in society and around the world. In the context of the Rwandan school curriculum, STEAM education is important to strengthening effective implementation of the Competence Based Curriculum (CBC).

2. Introduction

According to the National STEAM School Education Strategy (NSSES) document of Rwanda, The Rwanda Vision 2050 is about ensuring high standards of living for all Rwandans focusing on areas such as: quality of life; modern infrastructure and livelihoods; and transformation for prosperity. To meet those targets it is essential to achieve the highest possible quality of education to enable all citizens of Rwanda to build the advanced country that is envisioned to achieve.

It is vital therefore to ensure that the quality of STEAM Education is designed to prepare graduates of our education system with the skills and competencies they need to support Rwanda's vision. The mission of the Ministry of Education (MINEDUC) is to transform the Rwandan citizen into skilled human capital for the socio-economic development of the country by ensuring equitable access to quality education focusing on combating illiteracy, promotion of science and technology, critical thinking, and positive values.

Sustainable economic growth is a vital strategy for the future of Rwanda and the whole Africa. Therefore, new knowledge and technologies are needed to address emerging challenges and to underpin new goods and services. The growing sectors of Rwanda and the African economy require an increasing number of skilled workers with qualifications in STEAM. It is with this emphasis that the Rwandan government put the STEAM education as a priority area and developed the National STEM School Education Strategy (NSSES) to harness the full potentials of STEM education to empower the young talented and energetic citizens.

2.1 What is STEAM?

STEAM is an educational discipline that aims to spark an interest and lifelong love of the arts and sciences in children from an early age. Science, Technology, Engineering, the Arts and Math are similar fields of study in that they all involve creative processes and none uses just one method for inquiry and investigation. Teaching relevant, in-demand skills that will prepare students to become innovators in an ever-evolving world is paramount, not only for the future of the students themselves but for the future of the country.

STEAM empowers teachers to employ project-based learning that crosses each of the five disciplines and fosters an inclusive learning environment in which all students are able to engage and contribute. As opposed to traditional models of teaching, educators using the STEAM framework bring the disciplines together, leveraging the synergy between the modeling process and math and science content, for example, in order to blur the boundaries between modeling techniques and scientific/mathematical thinking. Through this holistic approach, students are able to exercise both sides of their brain at once.

"There is a dynamic synergy between the visual arts and the natural sciences," according to the article. "For example, science relies heavily on individuals with visual-art skills to render detailed

illustrations, depicting everything from atoms to zebras. Likewise, artists apply analytic, linear and logical thinking to compose and scale their work of art." "These parallel spaces of science and art are pulled toward each other by the education needs of the 21st century." STEAM education, they contend, is particularly important in the scientific disciplines because, "The next generation of scientists will need to develop their communication skills through both traditional means of writing and speaking, as well as more artistic means including illustrating, animating, videography, cartooning and model building.[1]

Beyond the classroom, both scientists and engineers use models including sketches, diagrams, mathematical relationships, simulations and physical models to make predictions about the likely behavior of a system. They also collect data to evaluate the predictions and possibly revise the model as a result. However, many engineers are not particularly comfortable with sketching; so connecting them with basic artistic skills through STEAM, and equipping them to better "see" their ideas, can help them become better engineers. Also considered to be very helpful in preparing secondary students to succeed in higher education, STEAM has gained popularity among educators, parents, administrators, corporations and other institutions.

2.2 Why is STEAM so Important?

In today's world, setting students up for future success means exposing them to these disciplines holistically in order to develop their critical thinking skills.

And the earlier students are exposed to the STEAM disciplines, the better. In a study by Microsoft, 4 in 5 STEM college students (78%) said they decided to study STEM in high school or earlier, and one in five (21%) decided in middle school or earlier. Yet, only 1 in 5 STEM college students feel that their K–12 education prepared them extremely well for their college courses in STEM. There also appears to be a major disparity in the female to male ratio when it comes to those employed in STEM fields. Getting more girls interested in STEAM disciplines is another facet of the movement.[2]

Not only does a STEAM framework teach students how to think critically, problem solve and use creativity, it prepares students to work in fields that are poised for growth. A report from the U.S. Bureau of Labor Statistics projects growth in STEM and STEAM-related occupations of 8% between now and 2029, compared to 3.4% for non-STEM occupations. It also lists median annual wages of $86,980 for STEM/STEAM jobs, compared to $39,810 for all occupations.[3] Even for students who don't choose a career in one of the STEM/STEAM fields, the skills students gain from a STEAM education can be translated into almost any career. An important part of this educational approach is that students who are taught under a STEAM framework are not just taught the subject matter but they are taught how to learn, how to ask questions, how to experiment and how to create.

[1] https://onlinedegrees.sandiego.edu/steam-education-in-schools/

[2] https://onlinedegrees.sandiego.edu/steam-education-in-schools/

[3] https://onlinedegrees.sandiego.edu/steam-education-in-schools/

2.3 STEM vs. STEAM

Before there was STEAM, there was STEM. The key innovator credited with updating STEM to STEAM by adding the arts is Georgette Yakman, an engineering and technology teacher who was the founding researcher of the STEAM educational framework in 2006.

However, the change was not about just "adding another thing" to STEM. Yakman explains that: "STEAM is about more than converging the fine arts and design thinking into STEM fields. The liberal arts are, the 'who & why,' the reasoning, to the 'what & how' of STEM."

2.4 Why the "A" in STEAM is Important in Education

The Rhode Island School of Design (RISD), one of the early champions of adding the arts to the original STEM framework to create STEAM, said that doing so emphasizes the vitally important "symbiosis between the arts and sciences." According to RISD, "The goal is to foster the true innovation that comes with combining the mind of a scientist or technologist with that of an artist or designer." Former RISD President John Maeda, an early influencer for STEAM, has emphasized the idea that design thinking and creativity are essential ingredients for innovation.

The addition of the 'A' (The Arts) to the original STEM discipline to create STEAM is important in part because practices such as modeling, developing explanations and engaging in critique and evaluation (argumentation), have too often been underemphasized in the context of math and science education.

Adding "the Arts" to STEM to create STEAM is about "incorporating creative thinking and applied arts in real situations," according to SteamPoweredFamily.com, "Art is about discovering and creating ingenious ways of problem solving, integrating principles or presenting information. Picture an architect, they use engineering, math, technology, science and arts to create stunning buildings and structures."

2.5. Innovation and STEAM Education in Africa

Primary, secondary and post-secondary education in Africa is relatively rare, and few schools have science labs. ASTEAM CoE has committed to leap ahead fast forward, bringing access to hands-on STEAM education not only to Rwandans, but also across Africa. In Rwanda, Some STEM labs have been established: STEM Power at University of Rwanda, STEAM Labs Africa, STEM center of UNESCO and also other STEAM centers in the region. Even though there are established centers, STEM labs and the Centers of Excellence have not yet achieved their goals.

In Nigeria, the STEM centre impact positively the students to foretaste what is required of their future careers. The same observations have been made in Sub-Sahara African countries like South Africa and Zambia. In Kenya, the STEM centres highlight the positive impacts of boosting the inspiration of the next generation towards STEM subjects and promotes the learners' creativity and critical thinking being problem –solver as well as being equipped with 21st-century skills. In the same

country, particularly Nairobi STEM centres contribute positively in the way of finding solutions to real-world problems through hands-on learning activities and creative design.

Although Africa holds nearly 17% of the world's population, its Science, Technology, Engineering & Math (STEM) capabilities fall behind the rest of the world. STEM education is a driver or economic performance and this essential for helping growing economies compete in the global market, create jobs (especially STEM jobs), and improve wealth. Despite lagging behind other regions in STEM, Africa has great untapped potential to transform its own and the global economy thanks to its unique demographic position, and African schools are a major part of this potential. Today, Africa has the world's largest population of young people. According to the United Nations World Population Prospects, over 60% of Africa's population is currently under 25, with Africa containing 19% of the global population of 15- to 24-year-olds. By 2035, sub-Saharan Africa will have a working population larger than the entire rest of the world combined. In contrast, other workforces in the world are aging. [4]

Due to this demographic asset, Africa has immense potential to improve its local and global economies, if it can produce a generation of young professionals that can take charge of the development of their countries. This is why it is critical for education in Africa to reach new levels, particularly with skills that can promote more STEM jobs.

Africa has the potential to contain some of the world's fastest-growing economies, but it can only compete with the rest of the world if it invests in STEM education for young people. Here is an in-depth look at the STEM education and STEM programs in Africa and what it can mean for Africa's future.

2.5.1. Benefits of STEAM Education for Africa

The STEM education is the back born of the teachers' training which improve the capacity of their teaching process and had a positive impact on universal basic education in terms of attendance, motivation, quality of learning, literacy, numeracy and science (Ismail, 2018). The research showed that the STEM centres will overcome the skills gaps in Africa related to numeracy, critical thinking communication, leadership, decision making and technical capacity. Solutions to minimize the challenges and improving STEM education in Africa will require collaboration between government and the private sector (George Fomunyam, 2020).

The STEM centers contribute positively to education as reported by the United Kingdom (UK). For example, the centre of excellent innovation of New York indicated the impacts of motivating and incenting research and education in high-skill, high-tech, high-value service innovation among

[4] https://thestempedia.com/blog/stem-education-in-africa-the-past-present-and-future/

institutions of higher education and accelerating technology transfer of these research findings from the laboratory to application in industry and the University classroom as well as employ multidisciplinary education and training to enhance the capacity and development of next generation of individuals and service offerings while maintaining the highest standards in STEM education

The STEAM programme will enable primary, secondary students to think faster, and enable them to be creative and learn fast their subjects as they will be learning by doing. In addition, as this programme will also have an Arts lab this will help students to learn by fun and unlock hidden abilities and improve their communication skills. STEAM education (Science, Technology, Engineering, Arts, Mathematics) is a multidisciplinary approach to learning that combines science, innovative technologies and creativity. It focuses on solving concrete problems whilst stimulating out-of-the-box and critical thinking, research skills and effective teamwork.

2.5.2. Implementation Challenges for the Adoption of STEAM Education in Africa

- STEM education in Africa has fallen behind compare to other regions due to a number of challenges, some of which include; inadequate facilities, lack of resources and basic amenities like electricity, water supply, restricted access to education, poor learning outcomes, low salaries of faculty, lack of research funding and equipment, as well as limited autonomy.
- In additional to that, limited educational infrastructure, staff shortages, low student attendance in school, weak governance, and lack of materials, poor content, poor condition of laboratory facilities and instructional media are the challenges that hindrance the path of better STEM education in Africa. (George Fomunyam, 2020)
- There is a myth in African culture that science subjects are hard to learn and this is due to the way science subjects are taught. African students believe the perceived notion that STEM fields are quite complex, and attaining success in these subjects are difficult. Most students just want to achieve high grades, and they are turned off STEM subjects because of this perception. They prefer to take art subjects or undertake majors they are sure they will excel and obtain high grades from. (Formunyam, 2020)
- Some students loose interest because their classrooms are not equipped with modern technological resources that enhance, and ensure ease of learning of these STEM subjects, which makes learning uninteresting and difficult. (Formunyam,2020)
- Primary and secondary schools in Africa have limited STEM labs due to budget constraints.
- In addition, there is a lack of skills for primary and secondary teachers in teaching practical skills of STEAM subjects.

Systematic and classroom challenges to providing quality STEAM education were identified in a previous working paper (Tikly et al. 2018).

Therefore, with this center of excellence, science subjects will be easier for students because they will be learning by doing and also with fun due to Art practical subjects.

2.5.3. How can Africa Embrace Innovation and STEAM Enabled Future?

The African Union's Agenda 2063 is a long-term framework intended to transform the African continent over 50 years. The agenda aspires that, by 2063, Africa shall be a continent where "well educated and skilled citizens, underpinned by science, technology, and innovation for a knowledgeable society is the norm and no child misses' school due to poverty…".

The African Union's Agenda 2063 aspires for inclusive growth and sustainable education programmes that can ensure skills revolution accentuating innovation, science, and technology. That is why the African Union Continental Education Strategy for Africa (CESA) aims to transform Africa's education and training systems to generate sustainable knowledge, competencies, skills, innovation, and creativity suitable for Africa's socio-economic development. As such, African countries are revitalizing and expanding access to quality education, harnessing the capacity of training systems, harmonizing education management and integration, and strengthening the science, technology, engineering, art and mathematics (STEAM) curricula. This includes disseminating scientific knowledge and promoting the culture of science within African society.

African countries need to develop skilled human resources to enable transformative innovation-led and knowledge-based economic development. This can be achieved through robust STEAM capabilities. To demonstrate this, some African countries such as Rwanda have recognised the significance of STEAM education and subsequently increased efforts towards reviewing their country's education curriculum. The revised curriculum places STEAM education as an important pillar of their education system. Such efforts have tremendously improved infrastructure investments, such as well-equipped STEAM laboratories, to make STEM more practical. Rwanda has significantly promoted STEAM education across all levels of study.

African countries are, therefore, encouraged to invest in STEAM education allowing students to perform experiments independently and improve their problem solving and critical thinking skills. STEAM activities provide a context for authentic problem solving and have the ability to reach more students than science, technology, engineering, and mathematics (STEM) alone (T. Roberts, 2020). To overcome the challenges faced by implementation of STEM education in Africa will require collaboration between government and the private sector(George Fomunyam, 2020). To support that ,collaboration with Swedish universities has boosted the research capacity at the University of Rwanda (Ismail, 2018). The impacts of training on teachers to move from single disciplinary to four disciplinary is also a key factors to minimize the challenges faced by STEAM (Milara & Cortés, 2019).

2.6. Initiatives Taken by ECA to Foster STEAM Education in Africa

According to UNECA, "technology and innovation play an important role in enhancing education, both as a sector and enabler, and in enabling individuals to determine their own future and one of the largest sectors of any country. However, this progress should be measured against the bigger picture: while primary school enrolment is about 80% the dropout rates remain high and very few are likely to complete secondary or tertiary education. Technology should help address gaps in access, equality and quality of education by generating alternative business models and options to bring quality and inclusive education to all, leading to **quality Science and Technology education for all in Africa**.". ECA is assisting African countries in the formulation, adoption and implementation of new technology and innovation policies that could facilitate the acceleration of the transformation process to improve their competitiveness.

2.7. Supporting the Establishment of STEAM Centers

The potential of STEAM education has been acknowledged worldwide, receiving growing attention from both educational researchers and practitioners. Furthermore, the future of economic growth largely depends on the availability of qualified engineering personnel, the beginning of which should be established at the secondary school level and continue in colleges and universities through the support and active implementation of STEAM education. In line to that, the results show that using STEAM-technologies in studying physical and mathematical disciplines by high school students of colleges and university students' performance, self-esteem improve, and creative abilities are developed.

In additional, including the arts in STEM learning can further enhance teaching and student achievement, and build upon existing approaches to STEM that encourage students to apply creativity to solving real-world problems. Technologies provide models that have the potential to improve students' learning outcomes, including development of higher-order thinking skills, and to expand the range of learning opportunities made available to students. Not only that, STEAM education in the form of cooperative teaching can arouse students' interest and promote teachers' professional development.

2.8. STEAM Education in Rwanda

The African Union High Level Panel on Innovation and Emerging Technologies (APET) encourages AU Member States to sustainably develop and inclusively implement practical and localised STEM education. APET believes that Africa's rapid economic growth can be accomplished by utilising scientific and technological research, development, and innovation that well-trained and skilled African STEM graduates adequately support.

To demonstrate this, some African countries such as Rwanda have recognised the significance of STEM education and subsequently increased efforts towards reviewing their country's education curriculum. The revised curriculum places STEM education as an important pillar of their education system. Such efforts have tremendously improved infrastructure investments, such as well-equipped STEM laboratories, to make STEM more practical.

Rwanda made tremendous efforts in promoting STEAM education across all levels of education. In 2015, Rwanda introduced an education curriculum referred to as the "Competence-Based Curriculum (CBC)" for basic education that is from pre-primary up to upper secondary education levels. This curriculum underpins building a knowledge-based, competence-based and technology-led economy through well-adjusted STEAM and Information, and Communication Technology (ICT) led education.

Rwanda has significantly promoted STEM education across all levels of study. For example, in 2019, Rwanda introduced the newly developed education curriculum referred to as the "New Competence-Based Curriculum" for pre-primary up to upper secondary education. [5]This new curriculum underpins building a knowledge-based and technology-led economy through well-adjusted STEM and Information, and Communication Technology (ICT) led education. Rwanda's Ministry of Education has partnered with technology-enabled companies such as Microsoft, O'Genius Panada, Zora Robotics and Class VR, and the Keza company, among others, towards incorporating STEM and ICT-enabled educational system. For example, this programme allows for the utilisation of ICT and other technologies to promote transferable skills such as critical thinking, problem-solving, and creativity.

Furthermore, the technology-enabled teaching in schools has effectively enhanced the efficiency of student-and-teacher interaction and teaching pedagogy. Such digital technology platforms enable students to collaborate and easily communicate with their teachers. In addition, teachers can administer tests, quizzes, examinations in a timely manner. With such digital technology-enabled assessment platforms, teachers and students can relay and receive timely feedback.

The Microsoft Technology teaching methodology utilises robotics to improve students' hands-on engagement and activities. These include students' exposure earlier on to computer programming and developing students' computational and logical thinking to solve real-life problems. This is accomplished by modelling problems and designing solutions. Furthermore, Rwanda's One-Laptop-Per-Child (OLPC) flagship programme has encouraged ICT-enabled primary school education. Consequently, through the OLPC flagship programme, Rwanda's ICT-enabled education has increased by up to 64% and 55% in primary and secondary schools, respectively.[6] In addition, the

[5] https://www.nepad.org/blog/rwanda-model-improving-stem-education-curricula-africa

[6] https://www.nepad.org/blog/rwanda-model-improving-stem-education-curricula-africa

Rwanda Coding Academy flagship programme has prepared Rwandan youth into future software developers and cybersecurity systems experts.

In addition to developing a technology-enabled education curriculum, the Rwandan education system has been designed such that it allows for extended time allocation for STEM-related subjects relative to arts-related subjects. As such, this is predominantly implemented at the primary school level. Further to this, Rwanda has significantly invested in essential STEM-related infrastructure such as laboratory equipment and accompanying material necessary for teaching STEM subjects. For example, in the past 25 years, Rwanda has equipped approximately 380 secondary schools with modern science laboratory tools. Even though there is still more work to be done, Rwanda's STEM outputs are progressively improving.

Rwanda's education policy emphasises training teachers enhanced teaching pedagogy on lesson delivery that links classroom learning with the local environment. The curriculum framework incorporates teachers capacity building that includes continuous professional development in school leadership, management, improvement planning, coaching, and mentoring. These capacity-building frameworks are put in place in Rwanda to address the barriers hindering the STEM uptake as any other African country. In this way, Rwanda can address the limited number of qualified STEM teachers and STEM teachers' inability to localise STEM teaching. Such measures have somewhat improved the STEM education uptake in Rwanda.

Digital skills training is now integrated into the national education system, in line with the government's commitment to leverage ICT as a cross-cutting enabler to propel the country's socioeconomic growth. More specifically, the national competency-based curriculum (CBC) includes basic digital skills at both the primary and secondary school levels, beginning with essential skills such as using computers, e-mail, and the internet in primary and lower secondary school, and progressing to specialized skills in programming, networking, and database management in upper secondary classes. However, gaps in access to key enablers in schools, including connectivity, digital devices, reliable electricity, digital content, and adequate teacher capacity, continue to adversely affect both the integration of ICT in the classroom and delivery of digital skills training. However, gaps in access to critical enablers in schools, such as internet connectivity, digital devices, digital content, and enough teacher capacity, continue to impede both ICT integration in the classroom and digital skills training delivery. For example, by the end of 2022, 47% of secondary schools had access to ICT devices under the SMART classroom scheme, while 58% of primary schools reportedly got laptops and tablets for teaching and learning under the One LabTop per Teacher or School Leader program. Also, only 20% of primary schools and 58% secondary schools reportedly are connected to the internet.

For example, by the end of 2022, 47% of secondary schools were reported to have access to ICT devices through the SMART classroom plan, while 58% of primary schools were reported to have received laptops and tablets for teaching and learning through the One LabTop per Teacher or School

Leader program. Furthermore, only 20% of primary schools and 58% of secondary schools are currently connected to the internet. There are also efforts to increase digital content where by end of 2022, most of the textbooks are now available online and offline via the national learning platform, there are 48 edutainment episodes on youtube channel and these will be available on the nation LMS soon. Virtual laboratories for science subjects are also being developed. Initiatives to increase teacher capacity in ICT include the establishment of 61 Centers of Excellence (CADEI), 14 training centers for Math and Science using ICT, and the training and certification of 50% of secondary teachers (MCE), and 31% of primary teachers (MIE).

Despite the above developments, Rwanda still lacks the requisite quantity of digital specialists, as well as those of the required caliber, to drive the aspiration for cross-sectoral digital transformation. While most types of TVET colleges offer ICT courses, only a few are considered digital specialists. Furthermore, only a small percentage of TVET students pursue advanced-level ICT courses, and even fewer graduate. Some of the areas where Rwanda, like many other African countries, lags include game development, cloud computing, software testing, cyber security, and scientific computing. While there are a few private and public universities that offer cutting-edge technological degrees, few students can afford to attend. As a result, the breadth and depth of digital expertise available locally are constrained.

As a result, the government has sought to collaborate with for-profit training providers such as Andela to provide rapid advanced digital skills training in coding, as well as to attract world-renowned academic institutions such as Carnegie Mellon University, which opened its Africa campus in Rwanda in 2011. The Rwanda Coding Academy, aimed for TVET institutions, was created by the government in early 2019. Meanwhile, donor financing has aided the launch of a few smaller initiatives, such as WeCode. [7]

In conclusion, based on the STEM progress accomplished in Rwanda, APET advises other African countries to consider improving their STEM education programmes and investments. With robust STEM education infrastructure, students can easily perform experiments independently and improve their problem-solving skills as needed by the knowledge-based economy. African countries are urged to update their curricula to localise their STEM education and make it more practical to accommodate efficient methodologies of teaching science in schools. Finally, African Member States are encouraged to significantly invest in their country's STEM education.

[7] https://www.chronicles.rw/2020/01/31/rwandas-universities-teaching-basic-computer-skills-unfit-for-latest-tech-advances-world-bank/

3. The African STEAM Center of Excellence (ASTEAM CoE)

3.1. Rationale to Establish the STEAM Center

Africa is now a growth driver and new technologies play a determining role and STEM education will accelerate this break. The potential of innovation and STEM education in the economic and social transformation of Africa is of paramount importance. According to the ministry of education of Rwanda, the major rationale for introducing the national framework for the establishment of STEM centers is the need for the smooth implementation of STEM education and training programs across all levels of education and across the country. The new scheme also seeks to attain the long- and short-term objectives of promoting technological innovation and economic growth aimed at solving societal problems.

In addition to inspiring young minds, the increasing presence of STEM-related activities is thought to increase students' interest in science-related subjects in schools, promote their general knowledge and capacity in science, and contribute to the improvement of student exam scores in science subjects. The scheme can also provide useful background for career exploration opportunities in the future by enhancing the development of what is often called 21st-century skills. These include communication, computer and technology, teamwork and analytical thinking skills.

Rwanda has recently developed a National Science Technology, Engineering and Mathematics (STEM) School Education Strategy (NSSES) which aims to provide targeted strategies to improve the quality of teaching and learning in STEM areas in basic education. The NSSES is one of the strategies underpinning key Government strategies such as the National Strategy for Transformation which calls upon creating 1,500,000 (214,000 annually) decent and productive jobs.

The strategy sets out to analyse how the series of inputs are processed into expected outputs which contribute to the attainment of the NSSES objective and Rwanda's long-term goal of ensuring sustained economic and social development and becoming a globally competitive knowledge-based economy by 2050. Five key areas were identified to improve quality, access, and achievement in STEM programs at basic education level. These include:

- **Effectiveness:** it is key to ensure that students achieve the expected learning outcomes benchmarks and that the annual student intake to Technical and Vocational Education and Training (TVET) and higher education systems has the required competencies in literacy, math and science for these systems to sufficiently provide the skilled labour force demanded by employers.
- **Conducive Environment**: It is essential to provide a sufficient conducive environment to effectively teach and learn practical STEM subjects in pre-primary, primary, lower and upper secondary.

- **Efficiency**: It is important to strengthen students' readiness to study STEM subjects as early as possible, increase completion rates at primary, lower and upper secondary as well as the transition rates between these educational levels, and increase the annual student intake to tertiary education in STEM fields.
- **Equity**: It is important to ensure access and uptake of quality teaching and learning of STEM subjects especially in terms of gender, the urban/rural divide, and children with disabilities.
- **Governance Accountability and Finance**: strengthening issues of "Governance, Accountability and Finance" in the teaching and learning of STEM subjects.

The current pandemic has clearly illustrated that while we acknowledge that technology enabled learning presents many opportunities, especially through this pandemic period, there remain many challenges, and trade-offs, related to the most effective ways of delivering education through technology and remotely whilst ensuring equity and that some children are not missed out.

For a developing country like Rwanda, that has sought science as one of the critical tools of enhancing its growth, increased STEAM activities not only enhance meaningful learning but also provide the opportunity for the preparation of graduates who can contribute to solving societal problems and speed up national economic growth and development.

This scheme can also pave the way for creativity and innovation that are important to drive such development. In this context, the ECA has supported a number of African countries to promote and adopt new and emerging technologies to advance their development aspirations towards transforming their economies in the framework of the growing global digital and knowledge economy. To this end, ECA is planning to support the establishment of the African Innovation and STEAM Center of Excellence which is going to be located in the premises of the Rwanda Education board and run by the University of Rwanda, College of Education.

3.2. Anticipated Mission, Vision & Objectives of the STEAM Center

3.2.1. Anticipated Mission of the Center

The African STEAM Center of Excellence (ASTEAM CoE) will strengthen Science, Technology, Arts and Mathematics education by introducing hands-on enrichment programs in Science, Technology, Engineering, Mathematics and Arts disciplines for pre-University youth.

3.2.2. Anticipated Vision of the Center

The African Innovation and STEAM Center of Excellence aims to develop students to become lifelong learners of science, technology, Arts and mathematics, enabling them to meet the challenges in the 21st century, and from a wider perspective, nurturing versatile talents with different levels of

knowledge and skills for enhancing the international competitiveness to contribute to social economic growth of Rwanda, and Africa in General.

3.2.3. Anticipated Objectives of the Center

The objectives of establishing the innovation and STEAM center are to achieve sustainable economic development through STEAM education include:

- Developing a solid knowledge base among students and enhancing their interest in Science, Technology Mathematics and Arts;
- Strengthening student's ability to integrate and apply knowledge and skills; nurturing their creativity, collaboration and problem-solving skills; and developing talents/experts in STEAM-related areas to foster the development of Rwanda.
- Promoting the enrichment of knowledge and teaching in mathematics, science and technology by creating services and resources for teachers, administrators, and students while linking public schools with higher education, businesses and cooperatives for the future.
- Serving as an epicenter for the development or application and promotion of the highest standards of STEAM education
- Serving as a research center on science and technology based education
- Providing coding skills for the primary and secondary level school students
- Supporting high quality mathematics, science, and technology education in Rwanda.
- Providing professional development opportunities and innovations for classroom teachers and administrators.
- Serving as a resource for Innovation, math, science and technology materials and support.
- Assisting schools in curriculum, instruction, assessment improvements, and reform in STEAM education.
- Promoting collaboration and coordination of STEAM activities with school districts and cooperatives.
- Strengthening the skills and preparation of pre-service teachers.
- STEAM Curriculum mapping and alignment for standards-based instruction and assessment
- Supporting Technology professional development
- Providing opportunities for teachers to increase capacity in, and students to have the opportunity to learn / experience new technologies relevant to the current digital age.
- The Centre will also be a location where new technologies can be researched/trialed with a view to scaling up for schools in Rwanda and the region.

3.2.4. Statement of Purpose

STEAM is one of the critical pillar for developing creative and innovative solutions that are needed in Africa across a range of life-supporting fields such as health, food production, basic infrastructure, environment, manufacturing, etc.

The AISTEAM CoE is tipped to be a model Centre not only in Rwanda, but also the whole African continent to offer STEAM mentorship and training opportunities to students, teachers and researchers. The centre will encourage creativity, innovation, critical thinking, and problem-solving skills which are very relevant in this 21-st century.

The African STEAM Center of Excellence (ASTEAM CoE) is established in 2022 following initiatives by the Government of Rwanda in partnership with the United Nation Economic Commission for Africa (UNECA). The AISTEAM CoE is based in Kigali City under academic and administrative management by the University of Rwanda-College of Education (UR-CE) and the Rwanda Basic Education Board (REB).

The Governance of the centre is structured into 3 categories and made of (i) Training and research unit; (ii) Public and international relation unit; and (iii) the Human resources and infrastructure unit. The overall activities will be coordinated by the Director of the centre to ensure effective operationalization.

3.2.5. Expected Outcomes

Based on the National STEAM School Education Strategy (NSSES) document of Rwanda, "Rwanda aspires to become a knowledge-based, technological and innovative-led country in order to sustain its economic growth and transformation that will accelerate the move towards achieving high standards of living for all Rwandans. As such, there is increasingly emphasized human capital development to support the economic and social transformation of the country. For the human capital development, the GoR prioritizes higher-level applied science, technology and skills to positively transform its education systems starting with early stages of education. At the same time, recent development in policy frameworks and initiative programs in Africa and worldwide demonstrate the link between STEM and socio-economic development. In particular, STEAM education plays a critical role in the education system for the country to keep abreast of being competitive in the global economy.

STEAM education presents opportunities regarding the achievement and monitoring of the Sustainable Development Goals (SDGs) across various economic, social and environmental dimensions. However, Rwanda's aspirations for STEAM human capital development face challenges due to a scarcity of qualified teachers. Thus, Rwanda needs to accelerate investments in the development of current and future workforce skills in the fields of STEAM as well as soft skills (communication, analytical and critical thinking) for the demand-driven education systems in sync with employers' needs and in order to push out the knowledge frontier and address local challenges. Moreover, modern trends in education are aimed at creating effective teaching and learning of STEAM subjects. However, the question remains can effective education be achieved with modern and contemporary schools without an effective teacher? Teacher quality is at the core of an effective education, and this can be achieved through effective STEM teacher preparation, induction, and professional development programs. In other words, teachers have a crucial role in shaping the potential of students to become agents of a sustainable future. Therefore, there

is need to develop strategies for enhancing the professional competencies of teachers that are required for delivering STEAM competence-based curriculum."

Therefore, in line with the aforementioned facts, the expected outcomes of the establishment of the innovation and STEAM center are: -

- Boosted Students' ability to integrate and apply knowledge and skills across disciplines to solve authentic problems is strengthened through STEAM-related learning activities. Their creativity, collaboration and problem-solving skills will be enhanced while potential in innovation is unleashed.
- Enhanced coding skills of the primary and secondary school students.
- Strengthened Teachers' expertise in organizing and implementing STEAM-related learning activities is
- Enhanced expertise through sharing with their counterparts of relevant key learning areas and exchange with academics/specialists of STEAM-related fields, with professional capacity of teachers and collaboration within and across schools will be strengthened.
- Capacitated School leaders in STEAM education and nurture their knowledge for planning the implementation of STEAM education holistically and effectively at school level according to their school context to suit the needs and interests of students.
- Engaged primary stakeholders in the promotion of student learning in STEAM-related areas.
- Benefited Rwanda and the continent as a whole from the nurturing of a range of talents with different capabilities and at different knowledge and skill levels that fulfill the needs of economic, scientific and technological developments in the contemporary world, hence helping maintain the international competitiveness of Rwanda in STEAM education.

3.3. The Core & Fundamental Engagement Areas of the STEAM Center

- Continuous professional developments (CPD)
- Promoting and fostering research and training
- Improve coordination and leadership on STEAM education
- Support the state-led movement to ensure that the Nation adopts a common baseline for what students learn in STEAM
- Cultivate, recruit, and reward STEAM teachers that prepare and inspire students
- Create STEAM-related experiences that excite and interest students of all backgrounds;
- Supporting communities of practice
- Diversity of society
- Support states and school districts in their efforts to transform schools into vibrant STEAM learning environment.
- Digitalization of content (interactive content and virtual reality in teaching and learning)
- E-school management

3.4. Proposed Laboratories

A STEAM Lab is a wholly integrated learning environment for learning where everything from science, technology, Engineering, Art and mathematics to the curriculum and assessment support each other to provide hands-on learning. It's where learning can be personalized and motivating to engage all types of students. A STEAM Lab can allow students to learn, explore, collaborate and create, and problem-solve. STEM lab programs are designed to accommodate each grade. Program elements, including construction kits, classroom design, technology, curriculum, and scope and sequence, work together to advance students. Here are the list of anticipated laboratories under the Innovation and STEAM center:

3.4.1. Mathematics lab

The mathematics laboratory is a place where anybody can experiment and explore patterns and ideas. It is a place where one can find a collection of games, puzzles, and other teaching and learning material. The materials are meant to be used both by the students on their own and with their teacher to explore the world of mathematics, to discover, to learn and to develop an interest in mathematics. The activities create interest among students or in anybody who wants to explore, and test some of their ideas, beliefs about mathematics.

The activities in the maths lab should be appealing to a wide range of people, of different ages and varying mathematical proficiency. While the initial appeal is broad-based, the level of engagement of different individuals may vary. The maths lab activities listed here have been done with students and teachers of different grade levels. The activities are intended to give children an experience of doing mathematics and not merely for the purpose of demonstration. The maths lab provides an opportunity for the students to discover mathematics through doing. Many of the activities present a problem or a challenge, with the possibility of generating further challenges and problems. The activities help students to visualize, manipulate and reason. They provide opportunity to make conjectures and test them, and to generalize observed patterns. They create a context for students to attempt to prove their conjectures.

It is important to note that while in science experiments provide evidence for hypotheses or theories, this is not so in mathematics. Observed patterns can only suggest mathematical hypotheses and conjectures, not provide evidence to support them. (Sometimes, they may help to disprove a conjecture through a counter-example.) Mathematical truths are accepted only on the basis of proofs, and not through experiment. Mathematics laboratory is a place to enjoy mathematics through informal exploration. It is a place where anyone can generate problems and struggle to get a answer. It is a space to explore and design new mathematical activities.

3.4.2. Technology and Engineering lab

(Electricity, Electronics, solar, computer science, simulators, computer Engineering, Mechanical engineering etc.)

Basic Electricity lab:- is aimed to provide hands-on experience and basic knowledge of electric current and electronics to understand the operation of the fundamental electrical and electronic circuits. Provide students with a basic understanding of electrical principles and practice, this includes Electrical Terms and Measures, circuits, Wiring Materials and Practices, Motors, safety and Application, and other similar software skills will be given under this STEM lab.

Electronics lab:- is aimed to deeply learn practical electronic theory through hands-on experience of assembling their increasingly-sophisticated circuits. Students learn to design and implement their circuit designs to help solve community problems. Students utilize hand tools, e.g. wire cutters, screwdrivers, and pliers. They measure with instruments, e.g. multi-meters and oscilloscopes. They utilize electronic components, e.g. resistors, capacitors, transistors, integrated circuits, programmable microcontrollers, sensors, relays, servos, and motors. The students assemble those electronic components on reusable teaching tools known as "solder-less breadboards" and "powered lab-platform trainers".

Solar energy lab:- aims to Introduce students to a new and exciting form of renewable energy, Challenge students to apply their science and math knowledge in an enriching hands-on lab, and use color filters over the solar panels to isolate different wavelengths of light, The students discover whether the energy in varying wavelengths affects the amount of electricity produced by the panels, Students learn the voltage and current outputs for both series and parallel circuits: students discover how to connect panels into a “grid.”: Students appreciate the decrease in grid power when there is limited light.

Computer science lab:- This lab teaches basic computer skills, in a modern, environmentally-respectful smart class lab. students to learn the basics of computer programming, with SCRATCH programming language. SCRATCH is a programming language that turns STEM students from media consumers into media producers, enabling them to create interactive stories, animations, games, music, and art that can then easily be shared on the web. As students create Scratch projects, they learn important mathematical and computational ideas, while also gaining a deeper understanding of the process of design.

Simulations lab:- is aimed to teach scientific first principles and make the world’s invisible phenomena visible and explorable. Students can peer into the details of chemical reactions,

manipulate the useable world of genes and DNA, compress centuries into seconds to unlock evolution's gradual mysteries, or watch Earth's plates create massive landforms. The lab also Provides a molecular workbench for the visual and interactive simulations that can be shared and embedded right within your class. They offer these simulations for Biology, Chemistry, and Physics

Computer Engineering lab:- is more specialized and concerned with using engineering principles to solve problems using computer hardware. Students learn designing hardware and software interfaces. Prototypes are often used to help solve well-defined problems. students learn how to plan, design, build and test devices that perform a specific function. Arduino programming and interfacing with different types of sensors and actuators are included in the lab.

Mechanical Engineering lab:- aims students understand and engage them on hands-on practice concepts like: Newton's 2nd law/ demonstration, Newton's 2nd law/ demonstration track, Freefall, Projectile motion, Ballistic pendulum, Laws of collision/ demonstration track, Moment of inertia and angular acceleration, Moment of inertia and angular acceleration with, precision pivot bearing, Centrifugal force, Laws of gyroscopes/ 3-axis gyroscope, Mechanical conservation of energy/ Maxwell's wheel, Laws of gyroscopes/ Cardani gyroscope, Moments of inertia of different bodies/ Steiner's theorem with Cobra4, Moments, Modulus of elasticity / Youngs Modulus, Mechanical hysteresis, Hooke's law, Moments of inertia and torsional vibrations, Determination of the gravitational, constant/computerized Cavendish balance, Reversible pendulum, Density of liquids, The surface of rotating liquids, Flow Measurement / Ultrasonic Doppler effect, Mathematical pendulum, Harmonic oscillations of spiral springs, The velocity of sound in air with Universal Counter, The phase velocity of rope waves, Acoustic Doppler effect with universal counter, The velocity of sound using Kundt's tube and digital function generator, Resonance frequencies of Helmholtz resonators.

3.4.3. Science lab

(Physics, Chemistry, Biology, Environment, Earth and space, Animal, Health, life etc. sciences)

Physics Lab: this lab aims to practice a wide range of physics lab equipment to perform several experiments, including glass beakers, test tunes, items Scales, lenses, heat lamps, magnets, balls, pendulums inclined planes, etc.. It reinforces the knowledge gained by the students in the theory class by emphasising on the fundamental concepts of Physics. The lab also helps them to develop experimental and analytical skills through direct observation and activities. Physics is the study of matter — what is it made of? How does it behave? What laws or equations describe it? From subatomic particles, to the Big Bang, modern physicists study matter at a tremendous range of scales. There's a whole lot of interesting physics at the human scale, too.

Chemistry Lab: is aimed to provide hands-on practices on chemical synthesis, analysis, problem-solving, technical scientific writing and record-keeping, safe laboratory practices, chemical handling and disposal, ethical conduct, and laboratory practices.

Biology Lab: is aimed at students who will investigate biological concepts including the chemical basis of life, cell structure and function, metabolism, reproduction, genetics, evolution, biological diversity and classification, plant structure and function, animal structure and function, and ecology.

Environment Lab: This lab aims to Testing surface, ground, and drinking water to determine if they contain any number of contaminants, provide related analyses for air and soil, conduct tests that test for organic and inorganic compounds, Installing monitoring equipment that collects vital data, ooperating soil monitoring equipment, ssterilizing lab equipment according to generally accepted professional standards, mmaintaining adequate stocks of technical goods and equipment, ooffering technical support to professionals with third-party organizations, Interpreting results from tests conducted by others, eearth and space, animal, health, life.

Earth and space lab:- is about Earth and its place within the solar system and universe. It includes the study of the Earth's land, oceans, atmosphere, and all the life that lives there from animals to plants. It includes the water cycle, the carbon cycle, the rock cycle, and anything that gradually affects the Earth over time. The "space" part talks about the Earth's position in the solar system, and it also explores the solar system and universe as a whole. Animal, Health, life

3.4.4. Software skills development lab

Software skills Lab:- is aimed to provide hands-on experience with different aspects of Software development, providing students with an education that prepares them to take basic software development projects using different software development languages like Java, Python, C#, C++, PHP, Javascript. Coding skills, Database, spread sheets, word processing, presentation software, design and video skills, Social media, photo editing tools and other similar software skills will be given under this STEM lab.

3.4.5. 4IR Technologies (including Robotics, AI, IoT, Drones and etc.)

The objective of this Lab is to teach Coding and robotics in forms as short courses, training, Demonstrations, Research Analysis, etc. Using it as a tool to help beneficiaries master the difficult concepts faced in Mathematics and Sciences. Since robotics involves all the body senses, engaging with it provides an enthusiasm that makes learners persevere until they understand the topics that appears hard to them. This Lab will drive our education system to a high standard.

Robotics lab:- aimed to learn, brainstorm, and put together robots using various kits. Students learn new skills such as problem-solving, leadership, community involvement, communicating across different technology platforms, finding their passions, and teamwork, which will position them for success. Students can use LEGO Bricks to build models and bring them to life while learning teamwork and communication skills. The lab provides several interactive robotics classes and coding programs using LEGO bricks. Students in their robotics programs learn pseudo-coding, coding, robotics, and engineering principles. Students will learn to code and develop creative problem-solving skills as they play with this interactive educational toy featuring 3 brick-built LEGO Star Wars droids and over 40 interactive missions and buildable props. Dash makes learning to code. Students can give Dash voice commands and explore loops, events, conditions, and sequences.

Artificial Intelligence (AI) lab:- Students will learn to code on the AIWS platform with easy-to-use age-appropriate block-based programming tools bringing their AI projects to Life. Some of the programming software students will code & play with are Scratch for AI, Snap! for AI, Pocket Code, Phiro Code smartphone app, MIT App Inventor, Cognimates, Python, and Javascript.

Internet of Things (IoT) lab:- Students learn a basic understanding of IoT, home automation, and plant health monitoring. The activities focusing on experiential learning will help them develop skills such as DIY-ing, problem-solving, critical thinking, creativity, and teamwork. The lab helps the students to learn the basics of the Internet of things (IoT) and how to send data to the cloud (ThingSpeak) using ESP8266 Wi-Fi module; How to get retrieve data from ThingSpeak (Cloud) in an IoT system using revive and ESP8266; How to get the weather data for a location using API requests from OpenWeatherMaps API? Publish temperature and humidity data on ThingSpeak (Internet) using a DHT11 sensor, device, and ESP8266; Learn how to measure and monitor the soil moisture using revive and PictoBlox to keep plants healthy; Use a PIR Motion sensor to detect the movement or presence of a human in the room; Make a voice-activated light bulb using revive, Dabble and relay module and do home automation.

3.4.6. Mechatronics lab

This lab is meant to serve as an exposure to mechatronics. As Mechanical actuators will be exploted. The electrical drives for motors and relays are used. **It** is designed for students to develop a deep understanding of mechatronic systems through to completion of hands-on practical projects. students will learn about robots, machines, electronics, hydraulics & pneumatics, electrical motor controls, sensors, computer-aided design (CAD), programming, programmable logic controls (PLC), diagnostics, computer numeric control (CNC), and other topics that together form the basis of "smart" devices used in robotics and advanced automated systems. The lab provides students with the foundational skills of mechatronics applications in a wide range of career pathways; Provides students with a solid grounding in the basic principles of mechatronic systems; mechanical, electrical and electronic, fluid power, and control; Aimed at and suitable for students of all abilities and aptitudes;

Integrate academic subjects, careers, technical skills and knowledge, and 21st Century Skills; Using the Tetrix robotics kits students complete a series of engineering and robotics construction challenges using the Pitsco Tetrix platform;

3.4.7. Virtual Reality lab

Virtual Reality can be described as an artificial environment that has been created digitally. By providing the user's senses with information as realistic as possible, the user is presented with a version of reality that doesn't really exist, but that can be experienced as very convincing. VR is an important aspect of far more than computer games and movies – two popular areas of use. Whenever something is too risky, expensive or unpractical to do in real life, Virtual Reality is the solution. From flight simulators and virtual operating rooms to city planning and therapy, the technology allows us to take virtual risks to gain real experience and knowledge.

The Virtual Reality (VR) Lab is a unique facility in which one can walk through virtual reality representations of products that are yet to be realised using virtual reality technologies.[8] The lab enables students and staff to visualise designs, develop immersive VR environments, and to test new VR and AR technologies. The lab features three-dimensional (3D) projections on the walls and floor, as well as sensory feedback, so participants can manipulate objects like medical tools. They're able to feel the weight of an object, as well as the resistance of push back and pull creating a new level in the height of realism in a virtual environment. The VR Lab is home to an interdisciplinary team with the diverse skill set required to work effectively in VR and AR. The team will consists of experts in computer-aided design, 3D modelling, programming, IT, computer science and mechatronics.

3.4.8. General Purpose Innovation lab

The lab offers a blend of unique technology solutions designed to stimulate learning through the innovative life cycle utilizing computer-aided design, new digital fabrication tools and techniques for inventors and people who want to design, prototype and build things. 3D printing technologies are also be part of the innovation lab

3.4.9. Entrepreneurial activities lab

Entrepreneurship skills lab:- is aimed to provide elements of successful entrepreneurship, opportunity identification, and assessment, of the economic development potential of small business. Students will understand elements of Entrepreneurship such as finance, economics, management, marketing, production, and so forth, showing how these must fit together to create a whole organization. Also apply principles, concepts, and frameworks to real-world situations, including the

[8] https://www.deakin.edu.au/engineering/facilities/virtual-reality-lab

business plan alternative forms of work arrangements in the new economy balancing an entrepreneurial lifestyle, determining what success means, goal setting, and visioning.

3.4.10. Arts and design Lab

Arts and design lab:- is aimed to provide hands-on experience in developing artistic ability using a wide range of media. students will understand Elements of Art and the Principles of Design covering drawing, mixed media, painting, sculpture, printmaking, and written analytical skills. Students will be able to show their ability to use line, tone, texture, shape, form, pattern, color, mood, etc as well as produce a critical piece of work about a fine artist and a designer under this STEM lab. Concept of aesthetic design values will also be explored under this lab.

3.5. Proposed Organizational Structure

Organizational structure is the method by which workflows through an organization. It allows groups to work together within their individual functions to manage tasks. Traditional organizational structures tend to be more formalized with employees grouped by function (such as finance or operations), region or product line. Less traditional structures are more loosely woven and flexible, with the ability to respond quickly to changing business environments.

Organizational structures have evolved since the 1800s. In the Industrial Revolution, individuals were organized to add parts to the manufacture of the product moving down the assembly line. Frederick Taylor's scientific management theory optimized the way tasks were performed, so workers performed only one task in the most efficient way. In the 20th Century, General Motors pioneered a revolutionary organizational design in which each major division made its own cars.[9]

Today, organizational structures are changing swiftly from virtual organizations to other flexible structures. As companies continue to evolve and increase their global presence, future organizations may embody a fluid, free-forming organization, member ownership and an entrepreneurial approach among all members.

Organizational structure aligns and relates parts of an organization, so it can achieve its maximum performance. The structure chosen affects an organization's success in carrying out its strategy and objectives. Leadership should understand the characteristics, benefits and limitations of various organizational structures to assist in this strategic alignment.

[9] https://www.coursehero.com/file/p2h2cqqm/Organizational-structures-have-evolved-since-the-1800s-In-the-Industrial/

Considering the real hierarchical experience of Rwanda, we proposed the below indicated organizational structure for the STEAM Center. The job description and minimum qualification levels for each position are also stipulated.

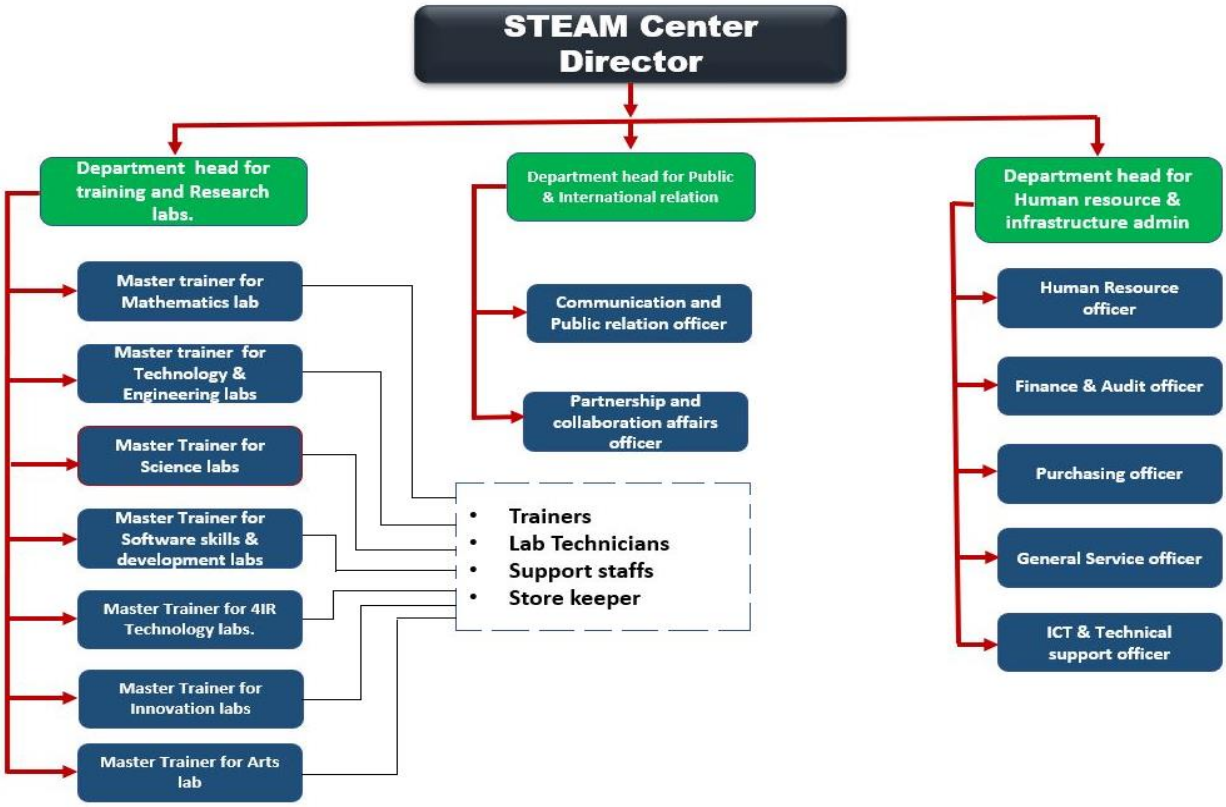

Figure 3.1 Proposed organizational structure of the STEAM Center

Director of the STEAM Center

1.1 Department head for Training and Research Labs

1.1.1 Master Trainer for Mathematics Labs
1.1.2 Master Trainer for Technology & Engineering labs
1.1.3 Master Trainer for Science labs
1.1.4 Master Trainer for Software skills & development labs
1.1.5 Master Trainer for 4IR Technology labs.
1.1.6 Master Trainer for Innovation labs
1.1.7 Master Trainer for Arts lab
1.1.8 Lab technicians
1.1.9 Trainers
1.1.10 Support staff
1.1.11 Storekeepers

1.2 Department head for Public and International Relation

1.2.1 Communication and Public Relation Officer
1.2.2 Partnership and collaboration affairs Officer

1.3 Department head for Human Resource and Infrastructure Administration Unit

1.3.1 Human resource Officer
1.3.2 Finance and audit Officer
1.3.3 Procurement Officer
1.3.4 General service Officer
1.3.5 ICT and Technical Support Officer

3.5.1. Human Resource Requirement

- It is expected that recruited staff will have minimum skills required, relevant and adequate to carry out their job tasks. Having experience in similiar respective areas would be a requirement to be able to guide and serve as mentors. Managerial and leadership skills are required for some staff, technical skills also are required for some other staff.
- Another requirement would be a relevant level of expertise for technical staff.
- Having a team spirit, flexibility, responsibility contributes to a harmonious working environment.

3.5.2. Job Description and Minimum Skills Required for each Position

The detail job description and the minimum required skills for each position are described in detail. Refer the Appendix section.

3.6 Proposed Office and Laboratory Facilities for the Center

3.6.1 Proposed office rooms

Table 3.1: Office facilities

No.	Offices	Quantity (Number)	Estimated Floor area (m^2)	Remark
1	Director Office	1	35	
2	Heads of Department Office	3	30 each	
3	Secretary Office	4	20 each	
5	Expert Offices attached to each lab.	10	12 m^2each	
6	Other Admin Workers Office	4	20 each	

3.6.2 Proposed Laboratory rooms

Table 3.2: proposed Laboratory rooms				
No.	**Labs**	**Quantity (Number)**	**Estimated Floor area (m^2)**	**Remark**
1	Mathematics lab	1	60	
2	General Science Lab 1 (Physics, Chemistry and Biology)	1	60	
3	General Science Lab 2 (Environment, Earth and space, Animal, Health, life etc. sciences)	1	60	
4	Technology and Engineering lab (Electronics, solar, computer science, simulators, computer Engineering) lab	1	60	
5	4IR Technologies (including Robotics, AI, IoT, Drones and etc.) lab	1	60	
6	Software Skills Development lab	1	60	
7	Mechatronics and Mechanical Engineering lab	1	60	
8	General Purpose Innovation lab	1	60	
9	Design and Visual Arts Lab	1	60	
10	Virtual and Augmented reality lab	1	60	
11	A store room attached to each labs	10	20	

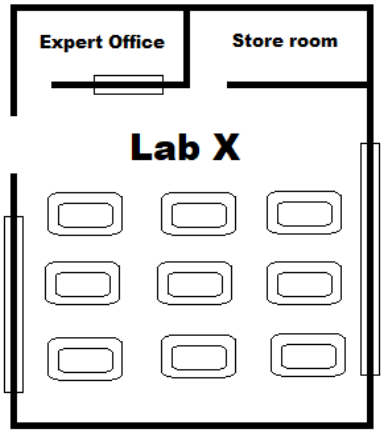

Table 3.3: Miscellaneous rooms				
No.	**room**	**Quantity (Number)**	**Estimated Floor area (m^2)**	**Remark**
1	Library	1	300	
2	Class rooms/lecture rooms	4	60 **m^2**each	
3	Smart class room	1	60	
4	Conference Room/video conferencing room	1	100	
5	Refreshment area/Cafeteria	1	200	
6	Data center/server room	1	40	
7	Materials and equipment Store Room	1	60	
8	Offices for various purposes	4	20 each	

4. Partnership and Collaboration Strategies

4.1. Background

According to the National STEAM School Education Strategy (NSSES) document of Rwanda, The Rwanda Vision 2050 is about ensuring high standards of living for all Rwandans focusing on areas such as: quality of life; modern infrastructure and livelihoods; and transformation for prosperity. To meet those targets, it is essential to achieve the highest possible quality of education to enable all citizens of Rwanda to build the advanced country that is envisioned to achieve.

It is vital therefore to ensure that the quality of STEAM Education is designed to prepare graduates of the education system with the skills and competencies they need to support Rwanda's vision. The mission of the Ministry of Education (MINEDUC) is to transform the Rwandan citizen into skilled human capital for the socio-economic development of the country by ensuring equitable access to quality education focusing on combating illiteracy, promotion of science and technology, critical thinking, and positive values. It is with these notions that the establishment of innovation and STEAM center is mandatory in Rwanda which could serve the whole citizens of Africa.

4.2. Purpose and Objectives of Partnership and Collaboration

It is important that the African Innovation and STEAM Centre of Excellence engages partnership and collaboration with national and sub-regional sector, either public or private. Across the nation, organizations are discovering the many benefits of partnering to accomplish far more than what might be possible working alone. Although there may be added value in working with other organizations, the benefits of effective partnerships don't occur overnight. Establishing successful partnerships takes time. The African Innovation and STEAM Centre of Excellence will engage in partnership and collaboration with the following objectives:

- Join efforts towards achieving its goals
- Avoid duplication and misuse of resources
- Share experiences and best practices
- Resources mobilization
- Promote awareness and utilization of the center for it to better serve its purpose

4.3. Overview of International STEAM Centers

The idea of having a STEAM Centre of Excellence is not new on global level. Such centers have been established in Kenya, Australia and Germany, Lebanon and Algeria. All of these Centers aim to inspire the next generation of Scientists, Mathematicians and Engineers and excite learners of all ages about the power and beauty of STEAM Education. They promote creativity critical thinking and

problem solving skills that are likely to help spur the economic growth at global level. They promote innovation workshops, training and seminars

In Rwanda, we have got Centers of Excellence, but they are at University Level such as African Centre of Excellence for Innovative teaching and Learning Mathematics and Science operating in University of Rwanda, College of Education. At the basic level we have got Rwanda Coding Academy.

4.4. Short listed International Innovation and STEAM Centers

4.4.1 Shortlisted leading international innovation and STEAM centers

- STEM Centre Africa, Kenya
- STEM Centre Australia
- International Centre for STEM Education, Germany
- STEAM Innovation Centre, Lebanon
- Algiers STEM Centre, Algeria
- Science Learning Centre for Africa, South Africa

4.4.2 Possible collaboration and partnership areas

The African Innovation STEAM Center of Excellence will collaborate and partner with relevant bodies in the following areas:

- Content development for capacity building
- Industrial attachment
- Resources mobilization
- Capacity development
- Knowledge and skills sharing
- Popularizing the STEAM Subjects

4.5. Short listed African Innovation and STEAM Centers and their activities

4.5.1 Emerging Innovation and STEAM Successes in Africa

a) **STEM Centre Africa, Kenya:** They developed basic computer lessons. They promoted STEM Education for girls whereby a pool of 6 girls participated in international competition. They develop online learning resources for different subjects for basic education.

b) **Algiers STEM Centre, Algeria**: This center is hosted by World Learning Algeria. World Learning is a non-profit Organization working in 75 countries worldwide. Algiers STEM Centre is one of the projects run by this Organizations since 2016. This

Algiers STEM Center is an industry-led initiative aiming to strengthen the innovation, critical thinking and communication skills of the Algerian workforce via direct training of youth, targeted teacher training and community education forums and events. With the center, students work on real-world problems in STEM fields, making connections between schools, community and the global world of work. The center trained teachers in interactive STEM teaching approaches and participate in an international robotics competition organized in the USA.

c) **Science Learning Centre for Africa,** hosted in University of Western Cape, South Africa: It is the community engagement extension of the school of Science and Mathematics Education in the faculty of Education. It is engaged in STEM teacher professional development, learning programs to popularize science amongst school learners, cutting –edge science education research, etc in order to transform the lives and empower communities. Among other successes they run the code and coding clubs whose aim is to develop skills in learners such as analytical thinking, problem solving, computational thinking and creativity.

4.5.2. Possible collaboration and partnership areas

- Content development and capacity building: Peer STEAM Centers may need to learn from each other, enrich together the content they deliver as well as the approaches they use.
- Resources mobilization: Peer STEAM Centers can undertake shared income generating projects to help implement their pre-determined goals and joint projects.
- Knowledge and skills sharing: This can be accomplished through peer learning and experience among members affiliated to the Centers and/or among partner STEAM Centers.
- Popularizing the STEAM Subjects: This can be done in STEAM exhibition events which is a way for students to make their learning relevant by sharing what they learn with a larger audience.
- Organization of STEAM Competitions: STEAM Centers can share they experiences in organizing and conducting national, regional and international competitions in STEAM subjects.

4.6. Overview of Potential Partner institutions and sectors

4.6.1 List of potential partners and sectors and possible partnership areas

Table 4.1 List of potential partners and sectors and possible partnership areas

Potential Partners/collaborators	**Address**	**Partner's core mission**	**Potential areas for partnership/collaboration**
Rwanda Coding Academy (RCA)	This is a professional upper secondary school located in Nyabihu District in Rwanda	Producing a pool of top-end experts in the field of software engineering in order to address the current shortages of software developers on Rwandan market and the region.	-developing academic program - organizing training - industrial attachment

African Institute for Mathematical Sciences (AIMS)	https://nexteinstein.org/ Higher institutions of learning dispatched in different African countries including Rwanda. The partnership/collaboration can start with AIMS-Rwanda	A pan-African network of centers of excellence enabling Africa's talented students to become innovators driving the continent's scientific, educational and economic self-sufficiency.	-development of academic programs -training teachers -resources mobilization through research projects -popularization of STEM
The African Centre of Excellence for Innovative Teaching and Learning Mathematics and Science (ACEITLMS)	https://ce.ur.ac.rw/The-African-Centre-of-Excellence-for-Innovative-Teaching-and-Learning ACEITLMS is one of 24 Eastern and Southern Africa Higher Education Centers of Excellence in the World Bank's ACE II Project.	The core aim of ACEITLMS is to strengthen human capacity in the delivery of quality teaching and learning of Mathematics and Science in Rwanda and across the region	- Development of academic program - teaching and learning, - resource mobilization - popularization
New Generation Academy	https://www.nga.ac.rw/ NGA is an international Christian school accredited with Cambridge Program	Serve and impact the community through educating, nurturing, and caring for the lives of children in a holistic manner characterized by godliness, creativity, and patriotism.	-industrial attachment -development of academic programs
Centre for Mathematics, Science and Technology Education in Africa (CEMASTEA)	https://www.cemastea.ac.ke/index.php CEMASTEA is a public institution under the Ministry of Education, Science and Technology (MOEST) in Kenya.	Its mandate is to build the capacity of mathematics and science teachers for effective classroom practices not only in Kenya but also in countries in Sub-Saharan Africa.	-Strengthening of Mathematics and Science Education -In-service Education and Training (INSET) programs.
Creativity Lab	http://creativity.rw/ Creativity Lab in Rwanda integrates TECH into the classroom	Creativity Lab works with schools to support teachers incorporate Creative Tech Playful in Teaching and conduct after school workshops for children in Programming, Engineering, Robotics and Artificial Intelligence	-developing academic programs -training teachers -resource mobilization

SOLEKTRA	www. Solektra.rw KBC building, 6th Floor Contact: 250782790270	SOLEKTRA is a leading provider of clean renewable energy solutions such as Solar Home Systems, Solar Street Lights, Solar Mini Grids, Smart Solar Irrigation, Water Solutions and other groundbreaking technological solutions. **SOLAR academy for STEAM** (quality training sessions, adapted to market needs and validated by official certification bodies) provide various training and entrepreneurship and digital Services and solutions to the community	**creation of SOLAR academy for STEAM** (quality training sessions, adapted to market needs and validated by official certification bodies; set up a large Solar Energy Laboratory, complying with international standards and equipped with the latest generation of equipment; equipments comprised: STEAM laboratories, Solar lighting, and others Digtal solutions needed by the Center) **STEAM Entrepreneurship** Create partnerships with STEAM Centers of Excellence to enrich our training sessions
SMART AFRICA	10th floor in Career Center Building, KG 541 ST, Kigali, Rwanda **Mobile: +250 788-300-581** **E-mail: info@smartafrica.org**	SMART Africa is a bold and innovative commitment from African Heads of State and Government to accelerate sustainable socio-economic development on the continent, ushering Africa into a knowledge economy through affordable access to Broadband and usage of Information and Communications Technologies (ICT). The pillars mentioned above are built on four, cross-cutting enablers which will support the implementation of SMART Africa. These enablers are (1) Innovation (2) Communications and Advocacy (3) Capacity Building and (4) Resource Mobilization.	Provide scholarships fund Support in providing equipment's and devices to the centers , Smart Africa Digital Academy for STEM (trainings for STEM entrepreneurs to engaged citizens with the aim of improving their digital literacy, so that they can fully benefit from the new potentials offered by digital technologies. Capacity building for STEAM staff - programs for digital inclusion, - Skills marketplace for professionals, Talent Bridge for businesses.

4.7. Collaboration Framework

Partnering with organizations that already have similar mission and vision with the AISTEAM is the most important task in order to achieve the centre goal. Various institutions and centres around the world are being engaged in promoting STEM education. This partnership will provide a strong foundation and operationalization of the centre. We therefore strongly encourage the AISTEAM to pursue a range of partnerships that include thought leaders in both the technical and societal aspects of STEAM education.

4.7.1. Partnership and Engagement Process

As noted previously, AISTEAM has set up clear goals and expected outcomes. Therefore, approaching partners becomes a relatively straightforward process. While looking for partnership, the AISTEAM should be prepared to answer the following questions:

- Why this partnership is necessary and what do we want to achieve with this collaboration?
- Who are the potential partners/collaborators that best serve AISTEAM's requirements?
- How do we begin the process of collaboration?
- How can AISTEAM leverage partners to promote and communicate its products?

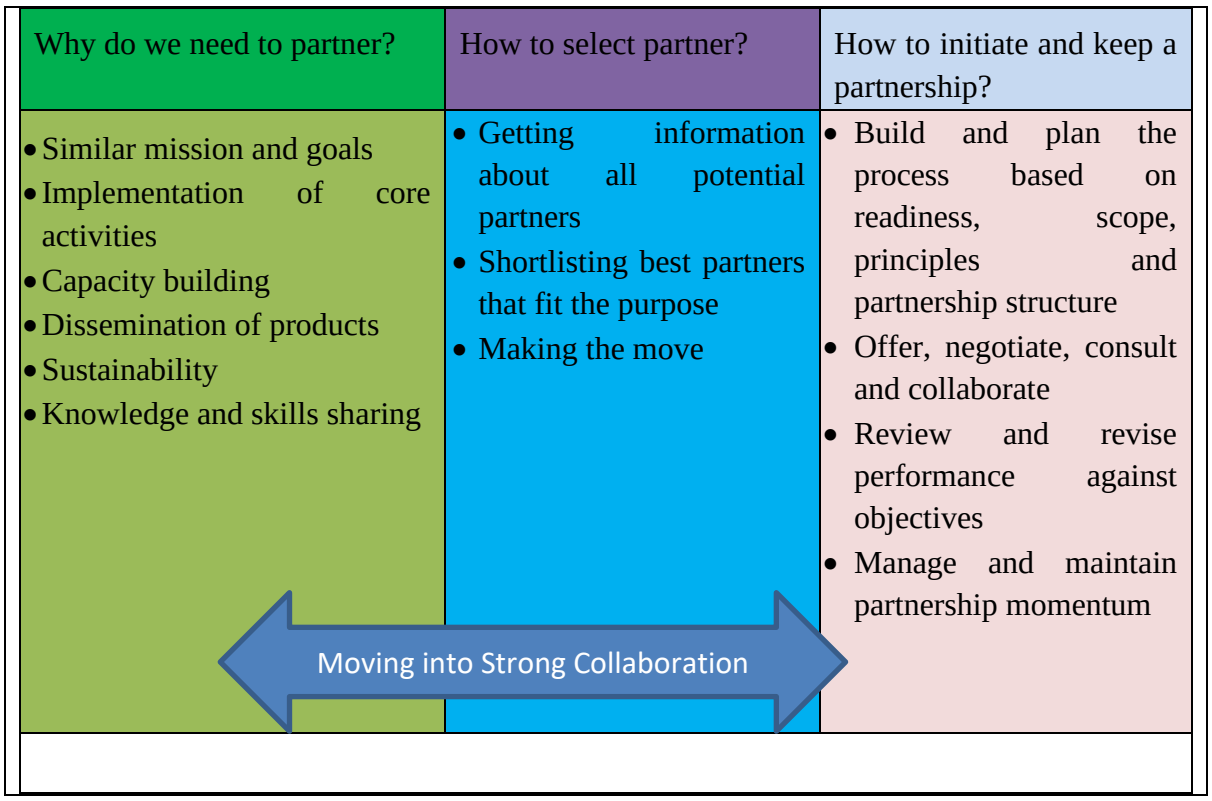

Figure 4.1 The basics of partnerships

4.7.2. Proposed Collaboration Framework

For any collaboration to be successful, both partners must be able and willing to commit to delivering on mutually agreed goals. Assessing ability is relatively straightforward and is reflected in the ranking data already presented. However, assessing willingness to deliver is more challenging, and requires clear and consistent communication. We therefore propose to create a formal framework for collaboration which will help ensure that all partners understand their respective responsibilities and expected contributions.

We anticipate that institution partners will contribute expertise in areas such as development of academic programs, research, lab equipment, infrastructure, popularization of products and capacity building. Learning from such top-tier partners will help AISTEAM establish world-class best practices and operating procedures. The combination of an agenda driven by Africa, for Africa, and global expertise, will position AISTEAM as the primary organization in Africa to help bridge the STEM quality education divide and engage Africa in 4th Industrial Revolution (4IR).

Holistic stakeholder engagement is critical to ensure relevance, impact and sustainability of AISTEAM. The following figure illustrates a holistic ecosystem of stakeholders.

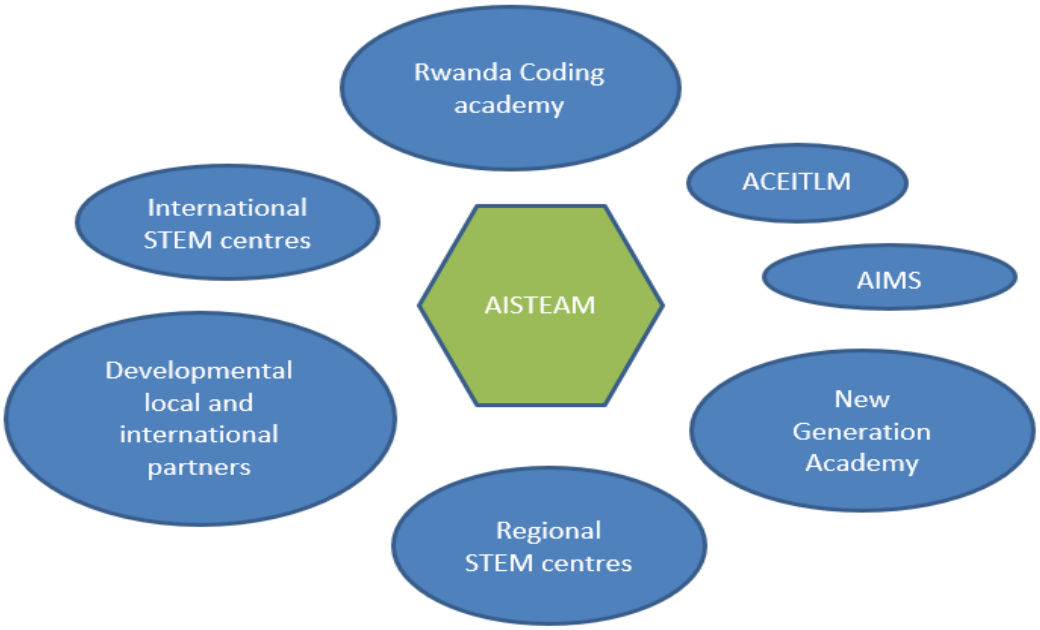

Figure 4.2 Holistic ecosystem of stakeholders

4.8. Recommendations and Way Forward

4.8.1. Recommendations

The STEAM Center will foster the development of STEAM education in Africa. It will support education and industry, providing a focal point for collaboration. As a centre of excellence, in partnership with world-leading institutions, it will be well positioned to drive change and support 4IR in Africa. More specifically, the STEAM center can play a key role in:

- Creating a vision for STEAM education in line with Africa's Agenda 2063
- Fostering collaboration between government, business and academic partners
- Identifying business-driven use-cases to study
- Acting as a catalyst for innovation through collaboration
- Nurturing and growing a network of STEAM education champions
- Communicating success stories and inspiring individuals, groups and corporations to get involved

As stated throughout this document, we believe goal-oriented partnerships with world-leading partners will be the most effective way for the STEAM center to proceed. The combination of a unique Africa-centric agenda with careful planning and execution will create a powerful force for change. It is critical to identify priorities and opportunities within the region and ensure a good technological foundation to achieve the desired outcomes. Creating the proper infrastructure and systems will set the stage for rapid growth.

As the STEAM center grows in stature through collaboration, it must start acquiring and building talent in other organizations. It is also critical that organizational structures and processes are evaluated on an ongoing basis. This can be achieved by measuring, empowering teams, processing design intelligence and building resilient infrastructure.

Greater ongoing efforts are needed to ensure that Africa is included in global studies of STEAM education and is an active participant in global conversations. Multi-channel communication strategies must be employed to ensure engagement and increasing awareness of the opportunities being created by the center. It is vital that the STEAM center engage with communities, schools, colleges, universities, industry and other key stakeholders.

4.8.2. Way Forward

Partnership and collaboration is the first of multiple steps required to establish the STEAM center as a world-class centre of excellence in Africa. We have clearly identified potential academic partners

and outlined a framework for collaboration. It is critically important that this initiative maintain its momentum going forward. Therefore, in Table 3, we propose a set of initial milestones for this project. With the support of partners from within and beyond Africa, we believe the STEAM center can be a powerful force for Africa's success in addressing social and economic challenges, and achieving inclusive, sustainable growth through a world class STEAM education.

Table 4.2: Proposed Tasks

Proposed Task	**Timeline**
Present recommendations to the STEAM center steering Committee	
Obtain formal approval for next steps to build partnerships	
The STEAM Center to confirm priority areas of focus	
Create formal partnership framework and engage with similar prospective institutions	
Formalize partnerships and collaboration framework with memorandums of understanding	
Develop a joint communication and co-branding strategy to drive awareness of the STEAM center work	
Leverage relationships to drive ongoing engagement with private sector companies and other strategic stakeholders	
Review of emerging research and potential partners in Africa and worldwide	

The STEAM center will play an important role in facilitating diverse expertise and perspectives, and coordinating efforts to ensure equitable and inclusive development and deployment of STEAM education in Africa. This includes promoting government-industry-research cooperation and cooperation with other academic institutions to draw on each other's strengths to achieve Africa's Agenda 2063 and the SDGs. Particularly, The Center will also play a key role in building relevant skills and nurturing Africa's youth and workforce to take full advantage of positive potential.

5. Budget Estimation to Establish the Center

5.1. Background

This section presents the estimated prices for **Capital expenditure**: equipment, facilities, website, logo etc, **Operational expenditure**: salaries, bandwidth, software and **Funding sources** are stipulated under this section. Estimated costs for all the required hardware and accessories for the data center; costs for all the required hardware and software for the proposed labs; costs for all office and lab furniture; costs for consultancy, content development and trainings, the construction cost to renovate the building is also included.

The budget estimation is done based on:-

- Considering the ten envisaged proposed sections and lab facilities
- Considering the proposed organizational structure
- Considering the current global material and equipment costs
- Considering the consultancy services needed
- Considering the training requirements needed to establish the center
- Considering the expertise needed for content development for capacity building training
- Considering the miscellaneous expenses for other costs

5.2. Lab and Office Furniture Requirement

5.2.1. Data Center Hardware and Equipment

5.2.2. Required Equipment & Software for the proposed sections and labs

Table 5.1: Hardware and software requirements for the proposed labs

No.	Equipment/Software	Quantity	Unit Price (USD)	Total Price (USD)
1	All the required Software packages for the required labs	8 Software packages	3,000	24,000
2	Workstation, Dell Precision 7920 Tower (2020)	4	3,000	12,000
3	Desktop Computers , Dell Inspiron 24 5000 Series All-in-One Touchscreen Desktop | 11th Gen Intel Core i7-1165G7 | 16GB RAM | 256GBSSD	60 (15 computers for each of the 4 labs)	1,000	60,000

4	GPU Laptop	4	2000	8,000
5	Switches, routers and Required Accessories for all labs sections	1	10,000	10,000
	Total			**114,000.00**

Table 5.2 Estimated budget for Laboratory Facilities for the Center (Refer the Appendix part for the detail)

SN	Name of the lab	Cost/USD
1	Technology and Engineering lab	$87,394
2	Science lab	$35,672
3	Software skills development lab	$20,200
4	4IR Technologies lab	$230,819
5	Mathematics lab	$7,000
6	Mechatronics lab	$269,700
7	Virtual Reality lab	$38,829
8	General Purpose Innovation and fabrication lab	$479,168
9	Arts and design lab	$7,000
10	Entrepreneurial activities lab	$5,000
12	Equipment and hardware for Smart classroom	$150,639
	Total cost	**$1,331,421**

5.2.3. Office Furniture and Digital Gadgets

Table 5.3: Office Furniture and digital gadgets costs

No.	Furniture	Quantity	Unit Price (USD)	Total Price (USD)
1	Swivel Office Chair	15	100	1500
2	Office Table	15	200	3000
3	Guest chair	50	100	5000
4	File cabinet	15	100	1500
5	Printer	5	2000	10000
6	Scanner	5	80	400
7	Computer Table	60	100	6000
8	Computer Chair	60	80	4800
9	Photo Copier	2	800	1600
10	Flat screen TV 75”	4	2000	8000
11	Book Shelf	30	100	3000

12	LCD Projector	5	500	5000
13	Big Conference Table	1	1000	1000
14	External Hard Disk (10 TB)	10	100	1000
15	Library reading table	20	200	4000
16	Library Chair	100	80	8000
17	Video Conferencing system	1	2000	2000
18	Interactive Smart board	4	1000	3000
19	Others			10000
20	Internet connection	1Gb/sec package for 1 year	2000	2000
	Total			**80,800.00**

5.3. Consultancy, Center website, logo, Content Development and Training

5.3.1. Consultancy Services

Table 5.4: Consultancy service costs			
No.	**Service**	**Duration/Months**	**Cost/USD**
1	Center Establishment Lead Consultant	4	32,000
2	Center building renovation and design Consultant	3	12,000
3	Operational phase consultant after the Center establishment	3	24,000
	Total		**68,000.00**

5.3.2. Center website, logo, Content Development and Training

Table 5.5: Center website, logo, Content Development and Training costs			
No.	**Service**	**Duration/Months**	**Cost/USD**
1	Content Developer	3	24,000
2	Training of trainers	3	24,000
3	Center Web site development	3	5,000
4	Center Logo Design	1	5,000
	Total		**58,000.00**

5.3.3. For the Existing Building repurposing and refurbishing purposes

Table 5.6: Existing Building repurposing and refurbishing costs			
No.	**Service**	**Duration/Months**	**Cost/USD**
1	Partitioning job based on the center needs	3	12,000
2	Electrical, Plumbing, air conditioning and etc. works	3	24,000

3	Painting and Finishing job	3	14,000
	Total		**50,000.00**

5.3.4. Salaries for the office holders and technical staffs for 1 year

Table 5.7: Salaries for the office holders and technical staffs for 1 year

No.	Service	Required No.	Monthly salary (USD)	Duration/year	Cost/USD
1	Center Director	1	2000	1	24,000
2	Center Deputy Directors	3	1500	1	18,000
3	Center Administrator	1	1000	1	12,000
4	Finance, Marketing, communication, sales and etc. officers	6	500 for each	1	36,000
5	Technical Staffs	6	500 for each	1	36,000
6	Civil Servants (Drivers, security guards, house cleaners, messengers and etc.)	10	150 for each	1	18,000
	Total				**144,000.00**

5.4. Estimated Total Project Cost

Table 5.8: Total estimated project costs

No.	Service	Source	Cost/USD
1	Hardware and software requirements for the proposed labs	Table 5.1	114,000.00
2	Estimated budget for Laboratory Facilities for the Center	Table 5.2	1,331,421.00
3	Office Furniture and digital gadgets costs	Table 5.3	80,800.00
4	Consultancy service costs	Table 5.4	68,000.00
5	Center website, logo, Content Development and Training costs	Table 5.5	58,000.00
6	Existing Building repurposing and refurbishing costs	Table 5.6	50,000.00
7	Salaries for the office holders and technical staffs for 1 year	Table 5.7	144,000.00
8	Total		1,846,621.00
9	Contingency	10% of total	184,662.10
	Grand Total		**2,031,283.10**

5.5 Funding Sources

In real sense, there is no right or wrong way to fund a project and look for funding sources and success might be found with just one approach or a combination of various ways to fund a project. Looking at different ways of funding encourages projects to behave like businesses and to think creatively about how to use available resources. When a project takes a broad approach to funding it can give them greater awareness and control of their finances.

A **grant** that could be given by the government of Rwanda or other organizations for this particular purpose could be considered as one sources of funding. **Partnerships with non-government organizations like UNECA and other sister organizations** could also help manage costs by sharing buildings, equipment, expertise and workloads. **Borrowing money from world bank or developed countries** could also be an option if the project can repay the loan.

Partnerships and collaborations with private companies in the sector could also be considered as a source of funding in terms of building the capacities of the technical people who will be employed in the cybersecurity center.

The STEAM Center needs to form joint collaboration research with local and international stakeholders and secure sufficient funds. Moreover, it's important to identify possible partnership areas where the center is mandated to carryout. The center seeks collaboration with similar institutes to work on joint projects that mitigate problems that society is facing at the grass-root level. Hence the center seeks sustainable research and development funding opportunities from partner actors to carry out cutting-edge problem-solving projects.

The bellow listed partners will have a vital role in implementing and Creating a Collaborative Environment, participate in Human resource capacity building, in building the STEAM center Infrastructure, in providing Research & Development Funding Opportunities, taking part in Experience sharing on STEAM education, R&D Practices and Organizational Setup:-

- Government of Rwanda
- Economic Commission for Africa (ECA)
- The African Union
- Local and foreign Private and government Universities
- Local and foreign Institutions and research centers engaged in STEAM education
- Local and abroad Science, Innovation, Technology and Engineering start-up companies
- Local and abroad Philanthropic and donor organizations
- Industries
- Public and private sectors
- Etc.

6. Plan of action

6.1. Short term plans (Three Months to One year)

Table 6.1: Short term plans of the STEAM CoE			
No.	**Actions**	**Deliverables**	**Implementation date 2023**
1	Validating and Endorsing the Strategic/establishment document.	Working strategic document	Mid-January /February
2	Forming Technical and steering committees	Responsible high-level committees	March
3	Assigning Interim Director, Experts and Secretary for the STEAM Center	Assigned Interim director and experts in the field	March to May
4	Purchasing and Fulfilling Office materials and lab equipment's for the STEAM Center	Equipped Laboratory and working place	February to April
5	Massive awareness creation through local medias, social medias and other possible information dissemination options should be done on the importance of establishing the STEAM Center to foster and support the nation and the continent economy	Massive awareness creation	April to May
6	Identify and list down local private sectors which are engaged in Technology, Innovation, Science, Engineering and related start-up projects for possible collaboration and partnership	List of local Start up project sectors	March to May
7	STEAM Center Management software development		February to April
8	Renovation of the STEAM Center building		January to April
9	Content development for the four identified labs	Developed learning modules	February to April
10	Designing and approving the Logo of the STEAM center	Approved logo	March
11	Developing web site for the STEAM Center and launching the page for public view	Public Awareness	March

12	Organizing the STEAM Center		May
13	Inaugurating the STEAM center with the four labs identified		June
14	Launching the center activities fully with all the labs		December

6.2 Long Term Plans (One to two years)

Table 6.2: Long term plans of the STEAM Center

No.	Actions	Deliverables	Implementation year
1	Finalizing the renovation work of the building to accommodate all the identified labs	Dedicated STEAM center building	
2	Fulfilling all the needed equipment, software, hardware and office gadgets of the STEAM Center	Equipped STEAM center	
3	Establishing state of the art STEAM center of excellence that could be the hub of research and development at the national, continental and global levels.	State of the art STEAM center	
4	Supporting STEAM education in Africa in collaboration with similar institutions and bringing them on the same platform for close collaboration and partnership	Strong partnership and collaborations	
5	Providing quality STEAM education and Consultancy services in Science, Technology, Engineering, Art and Mathematics fields	Knowledge distributions and giving quality of service to the community	
6	Creating strong link and collaboration with other similar research centers identified within Africa and abroad.	Strong partnership and collaborations	
7			
8			
9			
10			

7. Monitoring and Evaluation

Objective: To establish a Monitoring and Evaluation (M&E) mechanism to track and evaluate progress, evaluate, adjust and continually improve the outcomes and efficiency of the STEAM center.

Content: Suggested actions include determining M&E mechanisms that support timely and consistent monitoring and evaluation, and enable continual learning, and improvements to the engagement areas of the STEAM center. This includes defining indicators and identifying both qualitative and quantitative data sources. Suggestions are further made on developing a reporting structure and format.

Result: M&E mechanism, indicators and reporting format and structure.

7.1. Introduction

Based on the strategic goals, directions, expected outcomes, activities and outputs defined for the STEAM center, a final step in developing the framework is deciding on the monitoring, evaluation and reporting modalities. M&E is critical to track and review whether the implementation of the framework is progressing as planned and whether there is progress towards achieving expected outcomes. M&E is important to ensure learning and continual improvements of the STEAM center. M&E supports the determination of whether and how activities are being implemented (outputs) and whether transformative change is occurring by outcomes. This can help decide if additional activities may be required due to evolving needs and what adjustments need to be made. Regular reporting on M&E findings ensures transparency and accountability.

7.2. Guiding questions for monitoring and evaluation

- How can we best measure progress and document lessons learnt?
- How frequently should progress be tracked and reviewed?
- What M&E mechanism is most appropriate?
- Who should be responsible for M&E?
- Which indicators best measure progress?
- What format should the review have?
- Which reporting structures are needed?

The following suggested actions can guide the development of the monitoring and evaluation mechanism for the STEAM center.

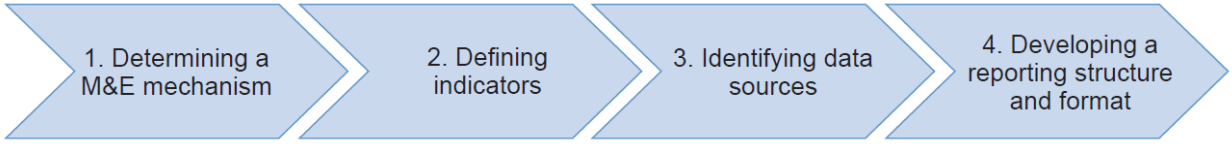

Figure 7.1 Monitoring and Evacuation Suggested actions

7.3 Determining a monitoring and evaluation mechanism

7.3.1. Establish mechanisms for timely and consistent monitoring

The monitoring and evaluation mechanism should make provisions for both a continuous assessment of progress on defined activities, outputs and expected outcomes (monitoring) as well as the periodic examination of the relevance, effectiveness, efficiency and impact of activities in light of the specified goals and objectives (evaluation). While monitoring activities can be organized and carried out through the mainstreaming mechanism put in place (the central coordination body, focal points of the STEAM center and members of the stakeholder network), the evaluation should be conducted by an independent entity to ensure independence, transparency and impartiality of the results and recommendations. The mechanism for monitoring and evaluation should ensure that lessons learnt are captured and feed into a continual adjustment and improvement of mainstreaming efforts. The scope of the monitoring and evaluation framework should be determined according to resources available for these activities.

It is recommended to determine how frequently the monitoring of activities, outputs and progress towards expected outcomes will be carried out. There may be different timelines for the monitoring of activities and outputs and of progress towards expected outcomes. For instance, progress on activities and defined outputs could be reported annually by focal points of the STEAM center, while it may be appropriate to have longer reporting cycles on progress towards expected outcomes, which may take a longer time span to achieve.

A participatory approach to assessing the implementation of the activities of the center involving all relevant stakeholders across government and society allows a broad examination of progress towards the objectives and outcomes of the planned activities, nurtures continuous stakeholder engagement and transparency of the process. A format that builds on ongoing stakeholder engagement in the M&E of all planned and implemented activities is recommended.

7.4Defining indicators

7.4.1 Select indicators to track progress

Indicators should be linked to each activity of the implementation plan to measure progress on defined outputs and expected outcomes of the center. Indicators may have already been developed for measuring progress of similar STEAM centers. If so, these indicators could be reviewed to assess their relevance to the goals, objectives and activities identified by the center.

7.5 Identifying data sources for monitoring and evaluation

7.5.1 Quantitative data

A core prerequisite for effective monitoring and evaluation is data availability. A lack of (disaggregated) data forms a constraint for monitoring mainstreaming efforts as the measurement of indicators is subject to the availability of relevant data. This may require planning the collection of new data and information and considering new approaches to data collection. The review of data in Stage 2 should help inform about available data and information sources that can be used to monitor outcomes and societal impacts of mainstreaming efforts. It should also point to existing data gaps that need to be addressed with new data collection at national and subnational levels.
In order to address data gaps, the application of non-traditional data or the use of non-official data sources can be considered after careful evaluation of reliability, including big-data, citizens-generated data or data collected from non-government data providers or stakeholders. Establishing an online platform or database that enables stakeholder collaboration on the collection of data can help broaden the data collection sources and engage non-governmental stakeholders as data providers**.**

7.5.2 Qualitative data

Some of the indicators identified as well as evaluation of the relevance, effectiveness, efficiency and impact of activities can be measured through qualitative information provided through interviews and surveys of key stakeholders and progress reporting by focal points of the center. Other sources of qualitative information can be available research or bottom-up participatory processes (such as seminars with stakeholders or research projects that explore ageing-related questions). Qualitative research can be commissioned to explore to what extent the objectives of the STEAM center are addressed in new policies and programmes. Qualitative information can also be obtained through consultations with focal points to assess to what degree communication, coordination, and collaboration have been enhanced to measure effectiveness of mainstreaming mechanisms put in place. The information obtained can respond to the defined questions relating to monitoring and evaluation but also generate new knowledge and insights about emerging concerns and challenges related to STEAM education.

7.6. Developing reporting structures and format

7.6.1. Strengthen accountability and commitment

As a part of determining the monitoring and evaluation approach it is important to define reporting structures (who reports to whom) and formats (how should information be reported). Guidelines for reporting can then be prepared accordingly. The reporting structure should ensure accountability to all engaged stakeholders. This is particularly important for the purpose of evaluation and assessment of progress as well as to applying lessons learned from one reporting period to the next. Implementing partners could be required to regularly report progress to the central coordination body, who in turn would communicate the findings from monitoring and evaluation exercises back to all stakeholders through periodic reports. Reporting structures should also provide an opportunity for stakeholders to provide feedback.

7.6.2. Raise awareness

Regular progress reports can form part of an overall communication strategy or applied as an awareness-raising activity on the center's over-all activities. It could be considered to create a forum or platform where reporting can be made publicly available, presented and discussed. In addition to enabling the communication of challenges and lessons learnt, a forum can be instrumental for making public the progress made on implementing the STEAM centers objectives. It can also help raise awareness on the most and peculiar engagement areas of the center that need attention and help ensure commitment among stakeholders to continue mainstreaming efforts in rapidly evolving contexts.

7.7. Checklist

- M&E approach considered
- Monitoring and reporting timelines determined
- M&E mechanism identified
- Data and information sources considered
- Indicators identified
- Reporting structure and format determined
- Participatory approach to M&E ensured
- Mechanism in place to ensure lessons learnt are used to adapt activities and improve the Strategic Framework

This section is designed just for providing strategies to monitor and evaluate the STEAM center programs and activities. A major aspect of expanding STEM education programs is providing compelling evidence of their effect. A well-planned evaluation helps the center understand, assess, document, and communicate issues of program effectiveness related to both implementation (i.e., which program elements are successful) and outcomes (i.e., what impact did the program have on

participants). These results are important for funders, program designers and/or implementers, and other stakeholders. The evaluation and monitoring section is not intended to provide an exhaustive description of STEM education evaluation practice and strategies, but rather to offer an overview of evaluation of the activities of the center in managing and facilitating it. As such, the purpose is to:

- Provide evaluation guidelines and resources for program leaders who are implementing STEAM programs in schools and community-based organizations.
- Reduce “evaluation anxiety” for individuals who are not professional evaluators by providing guidelines for good evaluation protocols.
- Offer suggestions on how to develop a comfortable and productive program-evaluation team relationship.
- Emphasize the role of program evaluation in helping inform STEAM education practice and policy.

8. Appendix

Annex A: Detail job description and the minimum required skills for each position in the center

Detail job description and the minimum required skills for each position				
No.	**Job Title**	**Job description/ role**	**Minimum requirement**	**Required No.**
1	**Center Director**	• Responsible to coordinate, manage and monitor the activities of the STEAM center • Represent the Center and contribute expertise in every consultative meeting about the Center • Encourage staffs of the STEAM Center to actively participate in the center activities	• A minimum of MSc. Degree in either of Mathematics, Software Engineering, Computer Science, Computer Engineering, Electrical Engineering or any other related Science and Technology disciplines • Good command of Communication both in English and French • Excellent communication and managerial skills • Experience in Administration • A strong ambition in establishing the STEAM center	1
1.1	**Department Head for Training and Research labs**	• The Deputy Director (for Training and Research labs) will drive the training and research agenda within the center to address continental and global development challenges in STEAM areas. This includes leading the identification of innovative training and research areas, ensuring relevance of thematic content for the development agenda that contributes to the United Nations Sustainable Development Goals (SDGs), and assuring the quality of outputs in STEAM education. • The Deputy Director will also play a key role in stimulating ideas and lines of investigation, synthesizing and communicating research findings to	• A minimum of MSc. Degree in either of Mathematics, Science and Technology areas including Software Engineering, Computer Science, Computer Engineering, Electrical Engineering or any other related disciplines • A minimum of 5 years of extensive experience in related areas of research, research for development, research institutions, development organizations and key stakeholders.	1

		key stakeholders, and in identifying and guiding the scaling up and scaling out of training and research findings. • The person will play a vital role in the overall management and direction of training and Research and technology developments in the identified STEAM labs.	• Proven ability to deliver training and research for development of international excellence, and demonstrable capacity to guide programs to deliver impact. Proven ability to create and lead a strategic vision. • Proven ability to manage a team to secure significant funding. • Proven ability to develop local and external collaborations with strategic partners. • Experience of teamwork and team leadership in a scientific and development context. • Scientific credibility as evidenced by sustained research outputs, for instance, publications in scientific journals, presentations at conferences, and successful research-led knowledge transfer in related research disciplines. • Demonstrable capacity to successfully motivate, manage and lead teams of different disciplines and multiple cultures to deliver on the research outputs and development outcomes described above. • Strong communication skills, both written and oral. • Ability to liaise with key donor agencies.	

1.1.1	**Master Trainers for the identified labs (**Head for Mathematics Labs, Head for Technology & Engineering labs, Head for Science labs, Head for Software skills & development labs, Head for 4IR Technology labs., Head for fabrication and 3D printing labs, Head for Arts lab)	• Developing objectives and designing training and research projects and proposals with their respective labs. • Formulating and conducting scientific experiments, performing data collection, and analyzing and evaluating test and research results. • Replicating, evaluating, and refining training and research strategies and approaches and recommending improvements, and testing, customizing, and implementing new methods and procedures. • Responding to training and research questions, troubleshooting problems, developing and writing advanced experimental protocols, and monitoring ongoing projects and proposing and implementing changes. • Proposing techniques to improve training and research quality and team productivity. • Contributing to and writing research findings for publications, papers, presentations, grants, and other documents. • Assisting with grant and manuscript submissions. • Guiding, training, and advising junior researchers and students, and supporting senior research staff.	• A Masters degree in respective fields of specializations or related field. • 3 years' teaching and research related experience. • Knowledge of teaching and research principles, concepts, practices, and methods. • Knowledge of scientific laboratory research techniques. • Computer literacy and strong mathematical, analytical, and research skills. • Excellent interpersonal and written and verbal communication skills.	7 (one head for each identified labs)
1.2	**Department Head for Public and International relation**	• A gate way for all the STEAM center activities • Facilitate innovation • Coordinate trainings • Strengthen team works • Coordinate seminars and workshops for STEAM center-Industry relationships • Coordinate coordination offices • Establish Sectors-University –Industry linkage • Strengthen student internship programs	• Master's degree in public and International relation or related field. • 3 years' work experience in related fields. • Knowledge of research principles, concepts, practices, and methods. • Knowledge of scientific laboratory research techniques.	1

		• Prepare memorandum of understandings • Identify potential stakeholders and partners • Evaluate implemented technology transfer projects • Support in protection of intellectual property rights • Follow up ongoing and completed technology projects • Facilitate the establishment of technology villages and parks • Provide guidance for STEAM and business and technology incubation centers • Participate national and international workshops, consortium, conferences and trainings	• Computer literacy and strong mathematical, analytical, and research skills. • Excellent interpersonal and written and verbal communication skills.	
1.2.1	**Communication and Public relation Officer**	• Responding to requests for information release or press conference from the media or designating a spokesperson or source of information. • Establishing and maintaining relationships with consumer, community, employee, and public interest groups. • Writing press releases and other media communications to promote clients. • Planning or directing the development of programs to maintain favorable public and stockholder views of the organization's agenda and accomplishments. • Coaching client representatives in effective communication with the public and employees. • Studying the center objectives, promotional policies, and needs to build public relations strategies that influence public opinion and promote products, ideas, and services. • Preparing and editing organizational publications, including employee newsletters or stockholders' reports, for internal and external audiences. • Updating and maintaining Web content.	• Bachelor degree in journalism, PR, marketing or related field. • Experience handling a press conference. • Excellent written and verbal communication skills. • Ability to pitch to media. • Knowledge of consumer marketing. • An ability to work on big strategy plans as well as day-to-day tasks. • Ability to think both creatively and strategically. • Ability to run PR campaigns that deliver measurable results and meet objectives. • Deadline-oriented, inquisitive, with great follow-up and reporting skills. • Understanding of social media and solid experience working with bloggers. • Project and budget management skills.	1

			• Responds well under pressure with strict time limit. • Quick and enthusiastic learner.	
1.2.2	**Partnership and Collaboration affairs Officer**	• Link the STEAM center to industry for mutual benefit. • Assist in the establishment of partnership with local and international organizations. • Organize the development of policies and guidelines of STEAM center industry linkage in collaboration with relevant institutions. • Link center staffs with industry for collaborative research, training and consultancy work. • Identify and prioritize trainings and researchable issues in collaboration with stakeholders. • Coordinate and facilitate the transfer and implementation of training and research outputs. • Arrange opportunities in industry for practical experience for STEAM center students. • Coordinate and facilitate the development of policies and oversees, the implementation of intellectual property rights.	• A Master's degree in public relation or related field. • 3 years' research related experience in Universities. • Knowledge of research principles, concepts, practices, and methods. • Knowledge of scientific laboratory research techniques. • Computer literacy and strong mathematical, analytical, and research skills. • Excellent interpersonal and written and verbal communication skills.	1
1.3	**Department Head for Human resource and finance administration unit**	• The Department head for Human resource and finance administration unit will be responsible for supporting the Director General of the STEAM center with the oversight and in-center leadership of financial reporting and administrative operations. In particular, s/he will support the human resource and financial operations for the project and conduct continual reporting to ensure the financial health of the project and the correct usage of funds.	• Minimum Bachelor’s degree in a relevant field (finance, accounting, business, etc.). • Minimum 5 years of relevant experience. • Excellent written and verbal communication skills and relevant computer software skills with proficiency in Excel. • Demonstrated ability to work effectively, both independently and in a team environment, in an atmosphere	1

			of multiple projects, shifting priorities, and deadline pressures. • Accuracy, attention to detail. • Fluency in English and French, written and oral.	
1.3.1	**Human resource officer**	• Developing and implementing human resources policies. • Supporting strategic objectives. • Hiring staff and negotiating employment agreements. • Ensuring compliance with laws and regulations. • Managing staff wellness and performance reviews. • Motivating and supporting current staff. • Maintaining staff records. • Handling employee benefits. • Identifying staffing needs and creating job descriptions. • Designing and directing training programs.	• Bachelor's degree in human resources management. • Excellent communication skills. • Highly organized. • Superior interpersonal skills. • Detail-oriented. • Good problem-solving skills. • Budget management experience. • Strong people skills. • Knowledge of labor laws and regulations. • Computer literacy.	1
1.3.2	**Finance and audit officer**	• Forecasting financial results. • Overseeing the budgets. • Conducting risk management. • Evaluating and initiating investments. • Allocating resources and managing finances. • Recommending cost reduction strategies. • Coordinating and developing internal auditing processes. • Developing and implementing policies and procedures. • Supervising and conducting independent audits. • Preparing analysis for departments. • Conducting investigations on irregularities and errors. • Drafting recommendations on corrective measures.	• Degree in accounting or finance. • Extensive experience in auditing. • Solid knowledge of regulations and guidelines. • A record of success in internal and external audits. • Excellent communication skills. • Strong time management skills.	1

1.3.3	**Procurement department officer**	• Developing and implementing purchasing strategies. • Managing daily purchasing activities, supervising staff, and allocating tasks. • Managing supplier relations and negotiating contracts, prices, timelines, etc. • Maintaining the supplier database, purchase records, and related documentation. • Coordinating with inventory control to determine and manage inventory needs. • Managing the maintenance of office/manufacturing equipment and machinery. • Ensuring that all procured items meet the required quality standards and specifications. • Preparing cost estimates and managing budgets. • Working to improve purchasing systems and processes. • Training new employees in the purchasing process and how to use the purchasing system.	• Degree in business administration or a related field. • Experience as a purchasing manager or in a similar position. • Deep knowledge of inventory and supply chain management. • Supervisory and management experience. • Proficiency in Microsoft Office and purchasing software. • Excellent communication skills, both written and verbal. • Strong critical thinking and negotiation skills. • Strong planning and organizational skills. • Ability to work independently.	1
1.3.4	**General service officer**	• Manage general service support operations and property administration; • Lead the development/adaptation of general services and property administration guidelines and procedures such as property admin, leases, motor pool, fuel and utilities management and maintenance, insurance, security and cleaning, canteen, etc; • Ensure the proper management and regular maintenance of all office vehicles, including rented vehicles, their gas usage and ensure that they are inspected and registered with government offices, repairs of property, grounds or utilities in the offices and also for expatriate housing;	• Bachelor's degree in Management, Property Administration • At least three years proven experience in similar positions having supervisory responsibilities; • Knowledge of general services and administrative systems, and development of working policy, manuals, procedures; • Excellent management, supervision/mentoring and organizational skills • Ability to work in a complex environment with multiple tasks, short	1

		• Ensure that all important documents related to general services operations and administration including contract agreements, correspondences are kept appropriately; • Ensure that office furniture and equipment inventory is regularly updated and ensure regular maintenance of office equipment as and when needed; • Work closely with HR office for tracking issues related to entitlements/working tools; • Oversee management of office stores for supplies and furnitures, ensure appropriate use of office stationeries, supervise office stationary stock and ensure cleanliness of store room;	deadlines and intense pressure to perform • Ability to work proactively, organize and manage own work and assist others to do the same • Computer literacy and ability to use all Office programs • Fluency in French and English is required	
1.3.6	**ICT and Technical support officer**	• Manage information technology and computer systems • Plan, organize, control and evaluate IT and electronic data operations • Manage IT staff by recruiting, training and coaching employees, communicating job expectations and appraising their performance • Design, develop, implement and coordinate systems, policies and procedures • Ensure security of data, network access and backup systems • Act in alignment with user needs and system functionality to contribute to the center policy • Identify problematic areas and implement strategic solutions in time • Audit systems and assess their outcomes • Preserve assets, information security and control structures • Handle annual budget and ensure cost effectiveness	• Proven working experience as an IT Manager or relevant experience • Excellent knowledge of technical management, information analysis and of computer hardware/software systems • Expertise in data centre management and data governance • Hands-on experience with computer networks, network administration and network installation • Ability to manage personnel • BS in Computer Science, MIS or similar field	1

Annex B: Contact Details of Leading Shortlisted International and African Innovation and STEAM Centers

No	Name of STEAM Center	Contact
1	STEM Centre Africa, Kenya	https://www.stemcenter-africa.com/
2	STEM Centre Australia	https://tutorssa.com.au/stem-centre
3	International Centre for STEM Education, Germany	https://icse.eu/about-us/what-is-icse/
4	STEAM Innovation Centre, Lebanon	https://www.ic.edu.lb/academics
5	Algiers STEM Centre, Algeria	https://algeria.worldlearning.org/algiers-steam-center/
6	Science Learning Centre for Africa, South Africa	https://www.uwc.ac.za/study/all-areas-of-study/centres/science-learning-centre-for-africa/what-we-do or https://www.uwc.ac.za/study/all-areas-of-study/centres/science-learning-centre-for-africa/overview
7	Allen ISD STEM centre, Texas (USA)	https://www.allenisd.org/domain/6139
8	STEM Learning (Also Called National STEM Learning Centre), University of York, UK:	https://www.stem.org.uk/ or https://www.stem.org.uk/about-us
9	STEAM centre education, Canada	https://www.steameducation.ca/about-us.html#/

10	STEAMLabs Africa, Nairobi, Kenya. This is a private social enterprise promoting STEAM Education	https://www.steamlabsafrica.com/

Annex C: Partnership and collaboration agreement document

Annex D: Laboratories List of items and kits

A. Technology and Engineering lab (Electronics, solar, computer science, simulators, computer Engineering, Mechanical engineering etc.)

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
KIT FOR ELECTRONICS					
1	Learning Kit Starter Kit	1. 1x Arduino Compatible UNO R3 (SMD version) 2. 1x Prototype Shield 3. 1x 830 Holes Large Breadboard 4. 1x Mini Breadboard 5. 1x LCD 1602 Display 6. 1x SG90 Servo Motor 7. 1x 5v Stepper Motor 8. 1x 5v Stepper Motor Driver 9. 1x IR Remote 10. 1 pack x Male to Male Breadboard Wire 11. 10x Female to Male Jumper Wire 12. 1x Potentiometer / Rotation Sensor 13. 4x Button with cap 14. 2x Buzzer 15. 2x Tilt Switch 16. 1x IC 74HC595N 17. 3x Light Dependent Sensor 18. 1x IR Sensor 19. 1x LM35 Temperature Sensor 20. 1x IR Receiver 21. 10x Resistor 220R 22. 10x Resistor 1K 23. 10x Resistor 10K	30	24,76	742,8

		24. 1x 7 Segment LED Display 25. 1x Dot Matrix 26. 1x 4 Ways 7 Segment Display 27. 10x LED 5mm Red 28. 10x LED 5mm Green 29. 10x LED 5mm Yellow 30. 1x 40ways Male Pin Header 31. 1x 9v Battery Snap with DC Plug 32. 1x 9V Battery 33. 1x USB Cable 34. 1x Small Component Box			
2	Keyestudio Raspberry Pi Pico Ultimate/Complete/Basic Sensor Starter Kit Education DIY Kit With MicroPython and Arduino Programming	The kit is a learning kit for two programming methods, including Thonny, MicroPython IDE and Arduino IDE. you can create numerous fascinating experiments with the Raspberry pi, sensors, modules and electronic components.	30	28.20	846
SOLAR KITS					
1	Solarparts 3V 250mA 62*120mm Solar Panel	This used Electric and Solar Energy Material: Solar Panel, Metal , Plastic	30	5.8	174

	DIY Educational Kits with Plastic Fan Motor and Alligator Clips Wires				
COMPUTER SCIENCE KITS					
1	Playz My First Coding & Computer Science Kit	Learn About Binary Codes, Encryption, Algorithms & Pixelation Through Fun Puzzling Activities Without Using a Computer for Boys, Girls, Teenagers, Kids	30	23	690
2	Boolean Box Build a Computer Science Kit for Kids	Includes Electronics, Coding, Animation and Lessons in Scratch, Python | Ages 8 and Up https://www.amazon.com/Boolean-Box-Electronics-Animation-Minecraft/dp/B071HWPKN5?th=1	30		
3	Kano Computer Kit – A Computer Anyone Can Make	This helps to Build your own computer. Comes with step-by-step book, Raspberry Pi 3, programmable LED lights, DIY case, power button, wireless keyboard with track pad, memory, HDMI and power cables, stickers, Kano unique operating system, 100+ coding challenges, and 100+ apps. New - learn to code with 100's of creative challenges and stories , Voltage - 5 volts Make art, games and music. Hack Minecraft to do something new. Plugs into any HDMI screen. Browse the internet, watch YouTube, write stories, 100+ apps.	30	499	14,970

SIMULATORS					
1	littleBits STEAM+ Coding Kit		4	429	1,716
COMPUTER ENGINEERING					
1	Design computers	https://www.mafraqenterprises.com/desktops/all-in-one-desktop-pc/hp-21.5-pro-one-600-g5-all-in-one-desktop-computer-core-i5-8gbram-1tb-hdd-storage/?gclid=CjwKCAjwzeqVBhAoEiwAOrEmza4_Bk5Ta6UdeR7SmilxpFmZphvO7mPrjsI40V9MXuZ5UzYBsTvyNhoCtKYQAvD_BwE Work Station - desktop 3.1 GHz Intel Core i7, 8GB of 2666 MHz DDR4 RAM, Integrated Intel UHD Graphics 630	5	675.70	3,378.50
2	Laptops	https://www.synovate.co.ke/en/products/dell-g5-15-gaming-laptop-windows-10-home-9th-gen-intel-core-i7-9750h-nvidia-gtx-1650-156-fhd-lcd-screen NVIDIA GeForce GTX 1650 with 4GB GDDR5 Graphics 9th Gen Intel Core i7-9750h (12MB Cache, up to 4. 5 GHz, 6 Cores) 16GB DDR4 2666MHz RAM	5	1,499	7,495
3	Projector	https://www.mafraqenterprises.com/accessories/projectors/epson-eb-e01-xga-3300-lumens-projector/?gclid=CjwKCAjwzeqVBhAoEiwAOrEmzYr1sdThxczNUSy5BEADISch7gHjcqs1kmZY88ppNwyD6_-QgDr-gRoC8FUQAvD_BwE Wattage 50watts	3	537.28	1,611.84

		Brightness 3300ANSI Lumen Controller type ButtonControl Item weight 2.4Kilograms Light source wattage 210Watts Minimum throw distance 2.02Metres			
4	Gaming Computers	https://www.lenovo.com/us/en/p/laptops/legion-laptops/legion-5-series/legion-5i-pro-gen-6-(16-inch-intel)/wmd00000493 i7 processor, NVIDIA Graphics card, 1TB storage	2	1,599.99	3,199.98
5	Highly portable camera	https://www.amazon.com/Canon-EOS-4000D-18-55mm-3-5-5-6/dp/B08KSMKHF3/ref=sr_1_25?crid=2R4UDBC4KL6TG&keywords=Highly+portable+camera+with+lenses&qid=1656260558&sprefix=highly+portable+camera+with+lenses%2Caps%2C306&sr=8-25 Brand Canon Model Name EOS 4000D Form Factor DSLR Effective Still Resolution 18 MP Special Feature Zoom Optical Zoom 3.06 x Color Black Connectivity Technology Bluetooth Screen Size 3 Inches Photo Sensor Size APS-C Advance lens	3	399.00	1,197
	Tripod	https://www.amazon.com/UBeesize-Bluetooth-Compatible-Projector-Spotting/dp/B08CHFY4R5/ref=sr_1_4?crid=3H8I8Y30YLPPK&keywords=Tripod&qid=1656260462&sprefix=tripod%2Caps%2C379&sr=8-4	3	36.99	110.97

		UBeesize 67” Camera Tripod with Travel Bag			
Mechanical Engineering					
1.	Engineering fundamentals Complete kit	Contains 19 Modular Engineering kits plus 10 Base Units, 2 Mobile Workstations and 1 set of spares Each Engineering kit is presented in an easily identifiable and durable storage tray with foam insert Complete Hands-on tray based system with clear lids making it easy to see their contents All kits are supplied with in-depth user workbooks providing a complete ready to go solution. Clear and concise assembly instructions for each experiment The Base Units can be set up horizontally, vertically and in inclined positions to suit each experiment Each Base Unit has a dimension of 51,5 x 39 cm Screen-printed design includes a measuring scale No assembly tools needed Backboard has a screen-printed grid reference which all assembly instructions refer to for the location of parts Simple grid reference system to assist with assembly of experiments The workstation can be used as a demonstration platform at the front of the classroom, but also doubles up as a storage unit for the experiment trays and Base Units. The workstation can be configured to store: - Up to 12 base units and a maximum of 18 trays (2 base units occupy the space of 1 tray) - 12 base units and 12 trays - 18 trays if storing no base units	1	29722.92	29722.92

		Castors are fitted to the Workstation which enable it to be easily moved between locations or when integrating in your classroom Supplied Engineering kits must cover the following curriculum topics : Forces Centre of gravity of plane figures: – Parallelogram – Rectangle – Semi-circle – Triangle – Irregular shape Analysis of 3 forces in equilibrium using: – Force triangles – Vector addition – Bow's notation – Graphical method – Mathematical solution Analysis of 4 forces in equilibrium using: – Force triangles – Vector addition – Bow's notation – Graphical method – Mathematical solution Analysis of non-concurrent forces (Linked polygons) Moments, Levers & Stability Beam Balance with Oblique Force 1st Class Lever 2nd Class Lever 3rd Class Lever Bell Crank Lever Beam Reactions			

		Stability of a Body: – Stable – Neutral – Unstable Equilibrium Centre of Gravity of a Body by Inclining at a known Angle Beams Analysis of beams under single point load conditions: – Simply supported beam – Fixed (encastre) beam – Propped cantilever Analysis of beams under two point load conditions: – Simply supported beam – Fixed (encastre) beam – Propped cantilever Analysis of cantilever beams under single point load conditions Analysis of beams under uniformly distributed load conditions: – Simply supported beam – Fixed (encastre) beam – Propped cantilever Analysis of cantilever beams under uniformly distributed load conditions Shearing Trusses Trusses, king post truss Trusses, warren truss Portals frame, pitched Portals frame, pitched with simple truss Portal frame, flat Catenary beam Springs Hooke’s law applied to compression springs, single spring			

		Hooke's law applied to compression springs in series Hooke's law applied to compression springs in parallel Hooke's law applied to extension springs, single spring Hooke's law applied to extension springs in series Hooke's law applied to extension springs in parallel Torsion Effect of rod length, rod material (Modulus of Rigidity) and 'J' value on angle of twist Friction Static and kinetic Friction Calculating the coefficient for both kinetic and static friction. Sliding and Rolling Friction Effect of Angle on Friction Component Forces Simple Harmonic Motion Effect of length and mass on period of oscillation of a simple pendulum Effect of length and mass on period of oscillation bifilar pendulum Effect of length and mass on period of oscillation trifilar pendulum Effect of length and mass on period of oscillation compound pendulum Measuring gravity using kater's pendulum SHM of a spring-mass system Rotational Friction Efficiency of a screw jack Efficiency of a wedge Efficiency of different bearings Mechanical advantage Velocity ratio Efficiency 'Overhaul'			

		Potential and Kinetic Energy Kinetic and potential energy in a pendulum Elastic (Potential) energy in a Spring Kinetic Energy in a Flywheel Energy Transfers Overcoming loses Centrifugal & Centripetal Force Relationship Between Centripetal Force, radius and Velocity of Different Rotating Masses Cam, Crank and Toggle Relationship between the angular movement of a pear, heart, round and snail cam and the linear movement of the follower Characteristics of a pear, heart, round, and snail cam profile Show characteristics of a rotating crank assembly by observing the motion of the system and observe the change in turning moment with crank angular position Turning moments and forces during crank motion Mechanisms Crank & slider Four bar linkage Oscillating cylinder Scotch yoke Slotted link quick return mechanism Whitworth quick return mechanism Conversion of motion using the Geneva mechanism Conversion of motion using a ratchet Bar linkages Four-bar linkages – crank rocker, double rocker, drag link and parallelogram Straight line linkages – Watt's straight line, Chebyshev, Peaucellier-Lipkin, Hart's inversor, Robert's and Hoeken's			

		Pantograph Ackermann steering Pulleys Weston differential pulley Windlass/wheel and axle Compound pulleys Moveable pulleys Fixed pulleys Capstan Gears Introduction to gear ratio, velocity ratio, efficiency of gears and mechanical advantage The advantages and disadvantages of different gears Transmission of motion between shafts S pur gear – parallel shafts Bevel gear – perpendicular shafts Worm gear – perpendicular overlapping shafts Rack and pinion – convert circular motion to linear motion Characteristics of spur gears, including single and compound gear trains and the ‘idler’ gear Gear terminology such as pitch diameter, number of teeth and centre distance Drive Systems Power transfer, efficiency and direction in a belt drive Power transfer and efficiency in a chain drive Input and output relationships of a universal coupling Friction and angle of lap on a pulley Tensile Tester Tensile tests (to destruction) of different materials Finding the tensile strength of a material Material behaviour in the elastic and plastic region			

		Creating a force and extension chart Technical Details : Base Unit Dimensions 51,5 x 39 cm Can be set up horizontally, vertically and in inclined positions to suit each experiment Screen-printed design includes a measuring scale No assembly tools needed Backboard has a screen-printed grid reference which all assembly instructions refer to for the location of parts Simple grid reference system to assist with assembly of experiments			
Energy Set		10			
	The storage box contains:	Storage box Molded insert EN Digital thermometer EN (-40 ° / + 70 ° C) 2-part solar module Peltier module Bosshead clamps, M2 Cord, 100 cm, in case Component capacitor 1F Cord, 50 cm, in case Building block incandescent lamp EN Copper pipe Pipe holder simple Tube holder for thermal sensors Friction body made of acrylic glass Spotlight 12 V / 20 W Hook ring Glass plate EN Stopwatch Pin with hook	1 1 2 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1	1,060.80	10,608.00

		Threaded rod	2		
		Rod with M5 thread, long	1		
		Steel pendulum bob	1		
		Isolation box EN	1		
		Aluminum plate EN	1		
		Wooden board EN	1		
		Acrylic sheet EN	1		
		Generator with bracket	1		
		Propeller	1		
		Force gauge, 5 N	1		
		Stand rod, 29 cm	2		
		Experiment leads, 8.5 cm	4		
		Measuring tape, 2 m	1		
		Weight, 50 g, with slot	3		
		Experiment leads, 34 cm	5		
		Drive pulley in case	1		
		Impact spring EN	1		
		Riders with screws	3		
		Ice cream pot	1		
		Weight holders, short	1		
		Aluminum cube with hook	1		
		Aluminum cube	1		
		LESLIE cube	1		
		Aluminum half-cube with hook	1		
		Screwdriver	1		
		Wooden block	1		
		Weight, 40 g, with slot	1		
	Additionally required:	Falling tube	10	73,82	738.20
		Acrylic plate 10 mm	10	7,84	78.40
		Calorimeter C7	10	21.41	214.10

		Solar module	10	66.40	664.00
		LED module	10	15.73	157.30
		Motor with propeller	10	48.48	484.80
		Waterwheel elements in case	10	48.93	489.30
Wind Energy kit 1 1,**899**.54 1,899.54					
		Influence of the wind speed Start-up wind speed of a wind turbine Comparison of the start-up wind speed of a Savonius and a three-blade rotor Change the turbine voltage by connecting a consumer Examine the wind speed behind the rotor Energy balance sheet at a wind turbine Calculating the efficiency of a wind turbine Storing electric energy Energy conversion in a wind turbine Examine colour wheels using a wind turbine Comparison of a Savonius rotor and a three-blade rotor Comparison of two, three and four-blade rotors Characteristic curves of a wind turbine Influence of the wind direction Influence of the rotor blade pitch Influence of the rotor blade pitch on the start up speed of a wind turbine Influence of the blade shape			
	Anemometer		1	452.16	452.16
	Accessories kit		1	3,318.00	3,318.00
Hydrogen-powered vehicle/car model					

		The kit is equipped with a Reversible PEM Fuel Cell to combine hydrogen and oxygen and produce electrical energy to power the motor. The hydrogen is supplied from a solar hydrogen gas station where the reversible fuel cell is run in electrolysis mode (in combination with the Solar Panel and De-ionized water) and splits water into hydrogen and oxygen. The gases are then stored for use in the storage cylinders where they are later transferred to the car and supplied back into the reversible fuel cell so it can be run in fuel cell mode to power the car Includes : Vehicle plate and accessories Reversible Fuel Cell Hydrogen/Oxygen/Air 2 storage tanks 1 solar module Classroom instruction booklet	10	336.00	3,360.00
Grand Total/USD					**87,394.21**

B. Science lab (Physics, Chemistry, Biology, Environment, Earth and space, Animal, Health, life etc.

LIST OF PHYSICS LABORATORY APPARATUSES					
N0	**Description**	**Unit**	**Required quantity**	**Estimated Unit Price USD**	**Estimated Total price USD**
1	**Ammeter 0-3a, moving iron**	**Pieces**	**45**	**2.77**	**124.65**
2	**Ammeter 0-5a, moving iron**	**Pieces**	**20**	**2.77**	**55.40**

3	**AMMETER SINGLE RANGE - MOVING COIL - SUITABLE FOR D.C ONLY - VOLTS DROP 75mv: RANGE 0 TO 1A**	**Pieces**	**20**	**3.40**	**68.00**
4	**AUDIO SIGNAL GENERATOR, FROM 1 TO 250 khz, 3 OUTPUT WAVE (TRIANGULAR, SINE, SQUARE)**	**Pieces**	**15**	**46.14**	**692.10**
5	**Balance, triple beam for animal weighing with masses cap. 2610gr**	**Pieces**	**15**	**35.37**	**530.55**
6	**Ball & ring apparatus**	**Pieces**	**20**	**2.00**	**40.00**
7	**Bar magnet with keeper in cardbox. Red and blue coloured at the ends to show north and south poles. 50 x 16 x 10mm (box of 1 pair)**	**Pieces**	**15**	**2.31**	**34.65**
8	**Bench power supply, continously variable, up to 30 volts**	**Pieces**	**15**	**92.28**	**1,384.20**
9	**Bench stand for soldering iron**	**Pieces**	**15**	**0.62**	**9.30**
10	**Bi - metallic strip, brass and steel, rivetted, with wooden handle thermostat bimetallic**	**Pieces**	**20**	**1.84**	**36.80**
11	**Bioconvex lens, diam. 51mm, focal length: 300mm**	**Pieces**	**45**	**0.46**	**20.70**
12	**BOSSHEAD FOR LABORATORY STAND CAST ALLOY FOR RODS UP TO 16mm**	**Pieces**	**45**	**0.68**	**30.60**
13	**CALLIPERS, SLIDING VERNIER MATT - FINISH 120mm X 0.1 mm**	**Pieces**	**20**	**0.93**	**18.60**
14	**Calorimeter set, copper joules. The unit is a nickel-plated copper calorimeter 75 x 50mm (diameter), lagged and enclosed within an outer vessel 100 x 75mm (diameter)**	**Pieces**	**45**	**5.38**	**242.10**

15	**GALVANOMETER 50-0-50 µa, RESISTANCE APPROX 1000 OHM**	**Pieces**	**20**	**3.84**	**76.80**
16	**Clamp, alum. Alloy with rubber sleeves, capacity 100mm**	**Pieces**	**45**	**1.69**	**76.05**
17	**Concave mirror glass - optical quality - back silvered protective coating diam. 50mm focus 100mm**	**Pieces**	**15**	**0.46**	**6.90**
18	**Concave mirror glass - optical quality - back silvered protective coating diam. 50mm focus 150mm**	**Pieces**	**15**	**0.46**	**6.90**
19	**Concave mirror glass - optical quality - back silvered protective coating diam. 50mmfocus 200mm**	**Pieces**	**15**	**0.46**	**6.90**
20	**Concave mirror glass - optical quality - back silvered protective coating diam. 50mm focus 300mm**	**Pieces**	**15**	**0.46**	**6.90**
21	**Convex mirror glass - optical quality - back silvered protective coating diam. 50mm focus 100mm**	**Pieces**	**15**	**0.46**	**6.90**
22	**Contact key single**	**Pieces**	**20**	**1.08**	**21.60**
23	**Convex mirror glass - optical quality - back silvered protective coating diam. 50mm focus 150mm**	**Pieces**	**15**	**0.46**	**6.90**
24	**Convex mirror glass - optical quality - back silvered protective coating diam. 50 mm focus 200mm**	**Pieces**	**15**	**0.46**	**6.90**
25	**SOFT BOARDS 40cm x 30cm**	**Pieces**	**45**	**2.15**	**96.75**
26	**COPPER WIRE, BARE, 0.31 mm ,30 SWG, 250 g**	**Pieces**	**5**	**7.69**	**38.45**
27	**COPPER WIRE, BARE, 0.31mm , 26 SWG, 250 g**	**Pieces**	**5**	**7.69**	**38.45**
28	**COPPER WIRE, BARE, 0.45mm, 28 SWG, 250 g**	**Pieces**	**5**	**7.69**	**38.45**

29	**COPPER WIRE, BARE, 0.56 mm, 24 SWG, 250 g**	**Pieces**	**5**	**7.69**	**38.45**
30	**COPPER WIRE, BARE, 0.71 MM 22 SWG, 250 g**	**Pieces**	**5**	**7.69**	**38.45**
31	**Copper wire, pvc insulated, black coated, gauge 22 ,100m length**	**Pieces**	**10**	**15.38**	**153.80**
32	**Copper wire, pvc insulated, red coated, gauge 22 ,100m length**	**Pieces**	**10**	**15.38**	**153.80**
33	**Crocodile clip strong spring, screw for clamp wire**	**Pieces**	**20**	**0.15**	**3.00**
34	**CYLINDER MEASURING TRANSPARENT, POLYPROPYLENE 1000cm3 X 10cm3**	**Pieces**	**15**	**2.31**	**34.65**
35	**CYLINDER MEASURING TRANSPARENT, POLYPROPYLENE 100cm3 X 1cm3**	**Pieces**	**45**	**0.43**	**19.35**
36	**Dc voltmeter, double ranges 0- 5v and 0- 15v d.c, plastic case, 0 adjustment**	**Pieces**	**45**	**3.39**	**152.55**
37	**DIFFRACTION GRATING AT 300 LINES/mm, IN 50 X 50 mm MOUNT**	**Pieces**	**15**	**3.39**	**50.85**
38	**DIFFRACTION GRATING AT 600 LINES/mm, IN 50 X 50 mm MOUNT**	**Pieces**	**15**	**3.39**	**50.85**
39	**DIFFRACTION GRATING AT 80 LINES/mm, IN 50 X 50 mm MOUNT**	**Pieces**	**15**	**3.39**	**50.85**
40	**DISPLACEMENT VESSEL, TIN 115 X 50 m WITH OVERFLOW**	**Pieces**	**45**	**1.53**	**68.85**
41	**Total internal reflection prism (90-45-45)**	**Pieces**	**15**	**1.53**	**22.95**

42	**DUAL TRACE OSCILLOSCOPE 20mhz, ECONOMICAL VERSION, 5mv SENSITIVITY**	**Pieces**	**2**	**445.99**	**891.98**
43	**FILTER FUNNELS, PLAIN POLTHENE 38mm DIAMETER**	**Pieces**	**15**	**0.21**	**3.15**
44	**Flash lamp bulbs, round m.e.s. 12v, 0.5a**	**Pieces**	**20**	**0.31**	**6.20**
45	**FLASK CONICAL WIDE MOUTH GRADUATED 500cm3 BOLOSILICATE**	**Pieces**	**45**	**2.31**	**103.95**
46	**FLASK ROUND BOTTOM BOROSILICATE 500cm3**	**Pieces**	**45**	**2.31**	**103.95**
47	**GAUZE, IRON, 20 MESH, 150 X 150 mm SQUARE**	**Pieces**	**15**	**0.25**	**3.75**
48	**GAUZE, IRON, CERAMIC CENTRE 125 mm SQUARE**	**Pieces**	**45**	**0.25**	**11.25**
49	**Hand operated vaccum and pressure pump, dia 10 inch with vaccum gauge**	**Pieces**	**10**	**30.76**	**307.60**
50	**Hand stroboscope simple form 255mm diam**	**Pieces**	**10**	**4.61**	**46.10**
51	**HARRIS MILLIAMMETER, SINGLE RANGE MOVING COIL, 0-10ma. D.C**	**Pieces**	**20**	**3.08**	**61.60**
52	**Hydrometer simple battery tester**	**Pieces**	**15**	**1.53**	**22.95**
53	**IRON FILLINGS IN SPRINKLER POT, 100 g**	**Bottles**	**5**	**0.62**	**3.10**
54	**LENS DOUBLE CONCAVE LENS, 38mm DIAM. FOCUS 150 mm, -6.6D**	**Pieces**	**15**	**0.37**	**5.55**
55	**LENS DOUBLE CONCAVE LENS, 50mm DIAM. FOCUS 200mm, -6.6D**	**Pieces**	**15**	**0.31**	**4.65**

56	**Lens double concave spherical - optical quality- ground edges- refractive index 1.52- diam. 38mm- focus 100mm- power d-10**	**Pieces**	**15**	**0.38**	**5.70**
57	**Lens double convex spherical - diam. 38mm - focus 50 mm optical quality ground edges - refractive index 1.52**	**Pieces**	**45**	**0.56**	**25.20**
58	**Lens double convex spherical - diam. 38mm , focus 100 mm optical quality ground edges - refractive index 1.52**	**Pieces**	**45**	**0.38**	**17.10**
59	**LENS DOUBLE CONVEX SPHERICAL - OPTICAL QUALITY- GROUND EDGES - REFRACTIVE INDEX 1.52- DIAM 38mm FOCUS 150mm POWER D +6.6**	**Pieces**	**45**	**0.38**	**17.10**
60	**LENS DOUBLE CONVEX SPHERICAL - OPTICAL QUALITY- GROUND EDGES - REFRACTIVE INDEX 1.52- DIAM 38mm FOCUS 200mm, POWER D +5**	**Pieces**	**45**	**0.25**	**11.25**
61	**Lens double convex- spherical- diam. 38mm- focus 300mm optical quality ground edges - refractive index 1.52**	**Pieces**	**45**	**0.31**	**13.95**
62	**Liquid level apparatus mouted**	**Pieces**	**15**	**1.84**	**27.60**
63	**MAGNADUR MAGNET 50 X 19 X 6mm**	**Pieces**	**45**	**0.15**	**6.75**
64	**CAPACITORS, 10,000µf,35V,+105°C MAX TEMPERATURE, RADIAL ELECTROLYTIC CAPACITOR**	**Pieces**	**15**	**1.53**	**22.95**
65	**METER RULE, HARD WOORD, NUMBERED EVERY 10 cm**	**Pieces**	**150**	**0.56**	**84.00**

66	**MICROMETER SCREW GAUGE, 0 TO 50 X 0.01 mm WITH LOCKNUT AND RATCHET IN CASE**	**Pieces**	**45**	**10.77**	**484.65**
67	**MICROSCOPE SLIDE 76 X 26 mm**	**Pieces**	**45**	**0.93**	**41.85**
68	**NICHROME WIRE, BARE, 0.45mm, 26 SWG, 250 g**	**Pieces**	**5**	**6.16**	**30.80**
69	**NICHROME WIRE, BARE, 0.56MM, 24 SWG, 250 g**	**Pieces**	**5**	**6.16**	**30.80**
70	**NICHROME WIRE, BARE, 0.71MM, 22 SWG, 250 g**	**Pieces**	**5**	**6.16**	**30.80**
71	**OPTICAL PINS FOR OPTIC EXPERIMENT NICKEL PLATED STEEL - HEAVY GAUGE - LENGTH 50mm (Pack of 100 pieces)**	**Packs**	**4**	**1.53**	**6.12**
72	**PERSPEX BLOCK RECTANGULAR 115 X 65 X 20 mm SURFACES FULLY POLISHED**	**Pieces**	**45**	**2.46**	**110.70**
73	**PLANE MIRROR, GLASS, 100 X 75 mm. PROTECTIVE COATING, BACK SILVERED(Pack of 10 pieces)**	**packs**	**4**	**1.84**	**7.36**
74	**PLOTTING COMPASS 16mm DIAM. IN METAL CASE**	**Pieces**	**15**	**0.21**	**3.15**
75	**Plug switch one way**	**Pieces**	**15**	**1.08**	**16.20**
76	**Plug switch two way with brass**	**Pieces**	**15**	**1.69**	**25.35**
77	**PORTABLE BALANCE, DISPLAY LCD, CAPACITY 600g, SENSITIVITY 0.1g, PAN SIZE: DIAM. 135mm, AIR PROTECTION, LOW BATTERY INDICATOR, AUTO OFF, BATTERY/ AC POWER (BOTH SUPLIED)**	**Pieces**	**10**	**9.23**	**92.30**
78	**POTENTIOMETER 1 METER- SINGLE WIRE 0.56mm WITH 4m WIRE, SOCKETS TERMINALS,**	**Pieces**	**10**	**6.16**	**61.60**

	JOCKEY WITH MOULDED RIBBED HANDLE - PLATED BRASS CONTACT WITH LOCATING NOTCH AND TERMINAL WITH 4mm SOCKED				
79	**PRISM, MADE FROM BOROSILICATE CROWN GLASS 600 X 600 X 600 mm REFRACTIVE INDEX 1,52 APPROX. POLISHED FACES, LENGTH 25mm, FACE 25mm**	**Pieces**	**45**	**3.08**	**138.60**
80	**Pulley, double sheave, plain bearing**	**Pieces**	**45**	**0.49**	**22.05**
81	**Pulley, single sheave, plain bearing**	**Pieces**	**45**	**0.25**	**11.25**
82	**Resistance substitution box, with 12 different values 100 ω , 220 ω , 470 ω , 1 k ω , 2 k ω, 4 k ω , 10 k ω , 22 k ω, 47 k ω , 100 k ω , 220 k ω and 470 k ω . All resistors are precision 1% resistors and are of 1 watt rating.**	**Pieces**	**15**	**7.69**	**115.35**
83	**RETORT STAND BASE, SIZE 200 X 125mm FINISHED WITH POWDER COAT AND RETORD STAND ROD SPARE, SCREWED THREAD, 600 X 12.5mm DIA.**	**Pieces**	**45**	**4.61**	**207.45**
84	**RHEOSTAT SINGLE TUBE, 16 OHM, 4A TUBE LENGTH 200mm**	**Pieces**	**45**	**6.16**	**277.20**
85	**RHEOSTAT SINGLE TUBE, 55 OHM, 2.3A TUBE LENGTH 200mm**	**Pieces**	**45**	**6.16**	**277.20**
86	**Ripple tank, dual purpose, free standing, accessories included**	**Pieces**	**5**	**46.14**	**230.70**
87	**SET OF CINEMOID FILTERS, MOUTHED, 50x50mm**	**Set**	**5**	**1.53**	**7.65**

88	**Set of four tuning forks, mouthed on a common box, for major chord demonstration**	**Set**	**15**	**10.77**	**161.55**
89	**SETS OF MASSES: 200g (20 g PER EACH MASS),500g (50g PER EACH MASS), AND 1000g (100 g PER EACH MASS)**	**Set**	**30**	**11.07**	**332.10**
90	**SET OF RODS FOR THERMAL CONDUCTIVITY EXPERMENTS 150X3 mm DIA., COMPLETE APPARATUS**	**Set**	**20**	**1.53**	**30.60**
91	**SIMPLE PEDULUM, BRASS, 20mm, DIA WITH A SMALL RING FOR SUSPENSION**	**Pieces**	**45**	**0.46**	**20.70**
92	**SOLDER WIRE, DIAM 1,2 mm, RESIN CORED WIRE**	**Pieces**	**15**	**0.77**	**11.55**
93	**SOLDERING IRON MINIATURE- 240V, 17w- 3 mm BIT**	**Pieces**	**15**	**3.84**	**57.60**
94	**Sonometer, simple pattern**	**Pieces**	**15**	**15.38**	**230.70**
95	**Spare pan for r 190145**	**Pieces**	**10**	**1.53**	**15.30**
96	**SPECTROMETER PRISM, CROWN GLASS 25 X 25 mm**	**Pieces**	**20**	**4.61**	**92.20**
97	**Spring balance, plastic body, flat scale, 0 to 10 n**	**Pieces**	**20**	**0.62**	**12.40**
98	**SPRING, EXTENSION, STEEL, 150mm LONG TIGHTLY WOUND 6mm DIA. 26SWG**	**Pieces**	**30**	**0.37**	**11.10**
99	**STANDARD SPECTROMETER TYPE HARRIS, COMPLETE WITH: 1PRISM CLAMP FOR PRISMS UP TO 40mm HIGH, A DIFFRACTION GRATING**	**Pieces**	**5**	**107.66**	**538.30**

	HOLDER, 25 X 25 mm, 1 TOMMY BAR FOR AXIS ADJUSTMENT INCLUDED SET UP INSTRUCTIONS AND TOOLS				
100	**Manometer**	**Pieces**	**15**	**1.84**	**27.60**
101	**TEST TUBES, SODA GLASS WITH RIM, 150 X 25 mm**	**Pieces**	**20**	**0.15**	**3.00**
102	**THERMOMETER, CLINICAL, 35 TO 43 DEG C X 0.1 DEG C LENGTH 110 mm**	**Pieces**	**20**	**0.46**	**9.20**
103	**THERMOMETERS, ECOLOGICAL RED LIQUID Y/B -10/110 X DEG C 76 IMMERSION, L 305 mm**	**Pieces**	**20**	**0.46**	**9.20**
104	**Stop clock. 2 buttons with laps and 1/100 second functions. 12 hour setting, lcd count/ down/up**	**Pieces**	**45**	**3.08**	**138.60**
105	**Traditional barometer aneroid**	**Pieces**	**15**	**3.08**	**46.20**
106	**Transformer with set of coils, model for demonstration**	**Pieces**	**15**	**12.30**	**184.50**
107	**TRIPOD STAND, TRIANGULAR, SPATIAL LOW FORM, SIDE 125mm HEIGHT 150 mm**	**Pieces**	**20**	**2.31**	**46.20**
108	**TUBING PRESSURE RUBBER, RED, FOR PRESSURE AND VACCUM WORK 3mm BORE X 4,5mm WALL, 10 m LONG**	**Pieces**	**15**	**4.62**	**69.30**
109	**TUBING, CAPILLARY, BOROSILICATE 0.5m LENGTH, 5mm OUT.DIA, 0.5mm INNER DIA.**	**Pieces**	**15**	**0.15**	**2.25**
110	**TUBING, SODA, BOROSILICATE GLASS 0.5m LENGTH 4mm O.D, 5 mm I.D**	**Pieces**	**15**	**0.15**	**2.25**
111	**U- SHAPED MAGNETS, 40 X 25 X 25mm**	**Pieces**	**10**	**2.46**	**24.60**

112	**Wheatstone bridge one mitre two gap- jockey included**	**Pieces**	**10**	**7.38**	**73.80**
113	**Wide flat solenoid**	**Pieces**	**15**	**10.77**	**161.55**
114	**WIRE HELIX (SLINKY) FLAT WIRE IN HELICOIDAL COIL – 75 mm- CLOSED LENGTH 55mm**	**Pieces**	**15**	**2.15**	**32.25**
115	**Drawing pins (pack of 100 pieces)**	**Packs**	**5**	**0.62**	**3.10**
116	**Electrostatic kit: 1 electroscope,1 rubber (polishing cloth),4 metalled polystyrene spheres,1 plated wire hook, 1 reel nylon monofilament,1 electrophorus plate on insulating handle,1 cellulose acetate strip, 1 polythene strip, 1 proof plane on insulating handle, 1 wire stirrup to support the above two items, 2 polythene tiles, 2 aluminum cans**	**SET**	**15**	**15.38**	**230.70**
117	**Basic optics light source, a single 10 watt quartz-halogen bulb, one, three, or five ray slit source**	**Pieces**	**10**	**5.38**	**53.80**
118	**Optical bench set with meterstick with their accessories**	**Pieces**	**15**	**2.46**	**36.90**
119	**Ordinary diodes in 4007 (si)**	**Pieces**	**10**	**0.31**	**3.10**
120	**HELICAL SPRING WITH POINTER, LENGTH 120 mm, AND 20mm DIA**	**Pieces**	**15**	**0.37**	**5.55**
121	**Digital compact multimeter (elenco), workable on 9 volt battery. Dc voltage range 200 v to 750 v, dc ampere 200 µa to 10 a. Resistance 200 to 2000 kΩ. Provided with test leads**	**Pieces**	**10**	**7.69**	**76.90**
				USD	**11,352.06**

C. Chemistry laboratory apparatuses

	LIST OF BIOLOGY LABORATORY APPARATUS				
No	Description	Unit	Required quanity	Estimated Unit Price USD	Estimated Total price USD
1	APPARATUS CLAMP, ALUM. ALLOY WITH CORK LINED JAWS, CAPACITY 90mm SHAFT DIA. 8mm	Pieces	45	1.69	76.05
2	BALANCE, TRIPLE BEAU FOR ANIMAL WEIGHING WITH MASSES CAP. 2610 gm x 0.1gm	Pieces	10	35.37	353.7
3	BEAKERS, GRAD. S.F BOROSILICATE WITH SPOUT 1000cm^3	Pieces	20	2.46	49.2
4	BEAKERS, GRAD. S.F BOROSILICATE WITH SPOUT 250cm^3	Pieces	45	0.93	41.85
5	BOSS HEAD FOR LABORATORY STAND CAST ALLOY FOR RODS UP TO 16mm	Pieces	45	0.68	30.6
6	BUNSEN BURNER, NATURAL GAS, HEIGHT 140mmTUBE DIA. 13mm	Pieces	15	2	30
7	BURETTE BRUSH, 15 X 150mm NYLON HEAD ON GALVANIZED WIRE STEM 900 mm OVERALL	Pieces	15	0.77	11.55

8	CHROMATOGRAPHY PAPER GRADE 1CHR. 19 X 23 cm	Pieces	150	3.08	462
9	CLINOSTAT, DISC DIA. 95mm, 240V VERSION	Pieces	15	41.52	622.8
10	CORK BORER SHARPENER FOR BORER DI. 5.24mm	Pieces	15	2.15	32.25
11	CORK BORERS, SET OF 6N/P BRASS DIA. RANGE 5 – 11mm	Pieces	15	2.15	32.25
12	COVER GLASS 18 X 18 mm PACK OF 10g	Packs	25	0.31	7.75
13	CRICIBLES, PORCELAIN, SQUAT FORM WITH LID, GLAZED, CAP. 15cm^3	Pieces	20	0.46	9.2
14	CULTURE BOTTLES	Bottles	15	0.31	4.65
15	CULTURES OF ESCHERICHIA COLI, BACILLUS SUBTILIS	Pieces	20	7.69	153.8
16	CYLINDER MEASURING TRANSPARENT, POLYPROPYLENE 10 0X 1cm^3	Pieces	45	0.43	19.35
17	CYLINDER MEASURING TRANSPARENT, POLYPROPYLENE 10 X 0,2cm^3	Pieces	20	0.37	7.4
18	CYLINDER MEASURING TRANSPARENT, POLYPROPYLENE 500 X 5cm^3	Pieces	20	1.24	24.8
19	DARK BLUE PLASTIC MODELLING CLAY PACK OF 500g	Pieces	15	4.62	69.3

20	DEWAR VESSELS, VACCUM FLASKS. 450cm^3 H 50 X 80 mm DIA	Pieces	15	4.62	69.3
21	DISSECTING DISHES, RECTANGULAR, ALUMINIUM 300 X 200 X 60mm	Pieces	20	9.23	184.6
22	DISSECTING DISHES, RECTANGULAR, ALUMINIUM 250 X 190 X 45mm	Pieces	15	7.69	115.35
23	DISSECTING SCISSORS, FINE POINTS, OPEN SHANKS, STAINLESS STEEL, 110mm	Pieces	45	1.53	68.85
24	DISSECTING SET 20 INSTRUMENTS IN WOOD BOX	Set	45	9.23	415.35
25	DROPPING PIPETTES, NARROW MOUTH CAPACITY 1.7cm^3	Pieces	150	0.02	3
26	EVAPORATING BASIN-BOROSILIVATE WITH SPOUT 80 X 45mm	Pieces	45	2.46	110.7
27	FILTER FUNNELS, PLAIN POLYTHENE, 62mm DIA.	Pieces	15	0.21	3.15
28	FILTER PAPERS WHATMAN STUDENT GRADE 110 MM DIA BOX OF 100 PAPERS	Boxes	5	0.37	1.85
29	CONICAL FLASK NARROW MOUTH GRAD. 500cm^3 BOROSILICATE	Pieces	20	2.46	49.2
30	FORCEPS, BLUNT ENDS STAINLESS STEEL, LENGTH 110mm	Pieces	45	0.46	20.7
31	GAUZE, IRON, 20MESH, 125mm SQUARE	Pieces	20	0.25	5

32	GRADUATED PIPETTES, (CLASS B) STRAIGHT FORM $10cm^3$ X $0.1cm^3$	Pieces	45	0.49	22.05
33	HAND HELD CENTRUFUGE COMPLETE WITH 4 PLACE ROTOR HEAD	Pieces	15	13.08	196.2
34	LONGITITUDINAL SECTION OF (LS) OF ROOT TO SHOW XYLEM VESSEL ELEMENTS AND SIEVE TUBE ELEMENTS AND COMPANION CELLS	Pieces	15	0.21	3.15
35	LOW VOLTAGE MICROSCOPE LAMP WITH 4mm PLUGS AND GROUND GLASS DIFFUSER, 12V, 15w	Pieces	20	3.08	61.6
36	LS OF STEM	Pieces	15	0.21	3.15
37	METER RULE, HARD WOOD, NUMBERED, EVERY 10cm	Pieces	150	0.56	84
38	MICROGRAPHS FOR COMPONENTS OF THE CIRCULATORY CYCLE	Pieces	15	4.6	69
39	MICROGRAPHS OF BLOOD SMEAR, BLOOD VESSELS	Pieces	15	4.6	69
40	MICROSCOPE STUDENT RANGE FINE & COARSE FOCUS X 4 X 10 X 40	Pieces	15	44.59	668.85
41	MICROSCOPE STUDENT RANGE STEREO VERTICAL X 10 EYE PIECE X 2 OBJ	Pieces	15	107.66	1614.9
42	MORTAR AND PESTLE, ALL PORCELAIN EXTERNAL DIA.80mm APPROXIMETLY	Pieces	45	0.93	41.85

43	NYLON TEST TUBE BRUSH, 200mm OVERALL LENGTH, TWISTED WIRE HANDLE	Pieces	15	0.31	4.65
44	OBSERVATION CHAMBER, 250 X 180 X 120 mm	Pieces	15	15.38	230.7
45	PIPETTE PASTEUR TYPE GRADUATED TYPE 3cm^3 CAPACITY LENGTH 155mm DISPO	Pieces	150	0.21	31.5
46	POCKET MAGNIFIER MAG. X 10 LOW ABBERATION, 15 X 25mm	Pieces	20	0.56	11.2
47	PREPARED AND PERMANENT SLIDES OF BACTERIAL CULTURES	Pieces	10	0.21	2.1
48	PREPARED MITOSIS SLIDES OF DIFFERENT PHASES	Pieces	10	0.21	2.1
49	PREPARED NERVE MUSCLE JUNCTION SLIDE	Pieces	10	0.21	2.1
50	PREPARED SLIDE OF BLOOD SMEAR	Pieces	10	0.21	2.1
51	PREPARED SLIDE OF TRACHEA TRANSVERSE SECTION	Pieces	10	0.21	2.1
52	PREPARED SLIDE ON MITOSIS	Pieces	10	0.21	2.1
53	PREPARED SLIDES OF PROKARYOTAE (E.G. BACTERIAL SMEAR, CYANOBACTERIA); FUNGI (E.G. YEAST, PENICILLIUM)	Pieces	10	0.21	2.1

54	PREPARED SLIDES OF CELLS AND TISSUES	Pieces	10	0.21	2.1
55	PREPARED SLIDES OF CELLS AND TISSUES	Pieces	10	0.21	2.1
56	PREPARED SLIDES OF CHEEK CELLS	Pieces	10	0.21	2.1
57	PREPARED SLIDES OF CROSS-SECTIONS OF XEROPHYTES	Pieces	10	0.21	2.1
58	PREPARED SLIDES OF NEURONS	Pieces	10	0.21	2.1
59	PREPARED SLIDES OF TESTIS AND OVARIAN TISSUE	Pieces	10	0.21	2.1
60	PREPARED SLIDES OF THE SENSE ORGANS	Pieces	10	0.21	2.1
61	PREPARED SLIDES OF TRANSVERSE SECTIONS (T.S.) OF LEAVES	Pieces	10	0.21	2.1
62	PREPARED SLIDES OF TRANSVERSE SECTIONS OF STEMS	Pieces	10	0.21	2.1
63	PREPARED SLIDES OF URINARY SYSTEM	Pieces	10	0.21	2.1
64	PREPARED SLIDES OF WHITE BLOOD CELLS	Pieces	10	0.21	2.1
65	PREPARED SLIDES OF XYLEM VESSEL ELEMENTS	Pieces	10	0.21	2.1

66	PREPARED SLIDES ON ROOT TIPS AND CHEEK CELLS	Pieces	10	0.21	2.1
67	RED PLASTIC MODELLING CLAY PACK OF 500g	Pieces	15	4.62	69.3
68	RETORT STAND BASE, SIZE 200 X 125mm, FINISHED IN POWDER COAT AND RETORT STAND ROD, SPARE, SREWD THREAD, 600 X 12.5mm DIA	Pieces	45	4.62	207.9
69	SCALPEL, STEEL HANDLE LENGTH 110mm BLADE LENGTH 38mm	Pieces	15	0.37	5.55
70	SEEKERS, HARD WOOD HANDLE, BENT OVERALL LENGTH 130mm, NEEDLE 95mm	Pieces	15	0.31	4.65
71	SIMPLE TUBE 'H' TYPE POTOMETER, CAP TUBE 140 mm GLASS TUBE 160 X 20mm DIM. BOROSILICATE GLASS	Pieces	15	4.62	69.3
72	SPATULA, POLYPROPYLENE 150mm AUTOCLAVABLE TAPERED SHAPE CHAMFERED ENDS	Pieces	45	0.25	11.25
73	STIRRING WATER BATH TANK CAP. 14LITRES DIGITAL TEMPERATURE INDICATOR CUM CONTROLLER WITH S.S TANK AND LID	Pieces	2	384.47	768.94
74	STOPPERS, RUBBER, SOLID ASSORTED B.S.2775	Pieces	15	0.09	1.35
75	STUDENT 200 BALANCE, 200*0.01g	Pieces	10	26.91	269.1

76	TEST TUBE BOROSILICATE GLASS MEDIUM WALL WITH RIM 150 X 24 mm DIA, PACK OF 100	Packs	2	0.25	0.5
77	TEST TUBES, SODA GLASS WITH RIM, 100 X 12mm DIA, PACK OF 100	Packs	2	0.09	0.18
78	TEST TUBES, SODA GLASS WITH RIM, 125X 13mm, PACK OF 100	Packs	2	0.09	0.18
79	THERMOMETERS, ECOLOGICAL RED LIQUID Y/B - 10/110 X 1DEG C 76 IMMERSION, L 300mm	Pieces	20	0.46	9.2
80	TRANSVERSE SECTION(TS) OF ARTERY	Pieces	10	0.21	2.1
81	TRANSVERSE SECTION(TS) OF BRONCHIOLES	Pieces	10	0.21	2.1
82	TRANSVERSE SECTION(TS) OF BRONCHUS	Pieces	10	0.21	2.1
83	TRANSVERSE SECTION(TS) OF KIDNEY	Pieces	10	0.21	2.1
84	TRANSVERSE SECTION(TS) OF LEAF OF DICOTYLEDONOUS MESOPHYTE (SUCH AS LIGUSTRUM OR PRUNUS OR LOCAL EQUIVALENT), MAIZE	Pieces	10	0.21	2.1
85	TRANSVERSE SECTION(TS) OF ROOT	Pieces	10	0.21	2.1
86	TRANSVERSE SECTION(TS) OF SPINALCORD(HUMAN, T.S. FOR GENERAL STRUCTURE PREPARED MICROSCOPE SLIDE)	Pieces	10	0.21	2.1

87	TRANSVERSE SECTION(TS) OF ANTHER	Pieces	10	0.21	2.1
88	TRANSVERSE SECTION(TS) OF LUNGS TO SHOW ALVEOLI	Pieces	10	0.21	2.1
89	TRANSVERSE SECTION(TS) OF STEM	Pieces	10	0.21	2.1
90	TRANSVERSE SECTION(TS) OF VEIN	Pieces	10	0.21	2.1
91	TRANSVERSE SECTIONS (TS) OVULE	Pieces	10	0.21	2.1
92	TRIPOD STANDS, TRIANGULAR, SPECIAL LOW FORM, SIDE 125mm, H: 154mm	Pieces	15	2.31	34.65
93	TUBING TRANSPARENT, PVC, BS 27513mm BORE X 0.75mm WALL COIL OF 10METERS	Pieces	45	3.08	138.6
94	VERTICAL SECTION OF (VS) MAIZE FRUIT	Pieces	15	0.21	3.15
95	VISKING TUBING, SIZE 2, NOMINAL DIA. 14mm ROLL OF 30METRES	Pieces	2	75.21	150.42
96	VOLUMETRIC FLASKS, STOPPERED (CLASS B) 1000cm^3	Pieces	20	3.53	70.6
97	VOLUMETRIC FLASKS, STOPPERED (CLASS B) 250cm^3	Pieces	45	1.69	76.05

98	WASH BOTTLE, POLYTHENE 250cm^3 OVAL SHAPE WITH SCREW CAP AND BENT TUBE	Pieces	45	0.38	17.1
99	WATCH GLASSES CONCAVE, 50mm DIAM. GROUND EDGES	Pieces	45	0.12	5.4
100	YELLOW PLASTIC MODELLING CLAY PACK OF 500g	Pieces	10	4.61	46.1
101	SWEEPING NET (MUSLIN)INSECT NETS, A LIGHT WEIGHT, ROBUST INSECT NET WITH 800MM LONG HANDLE	Pieces	10	7.69	76.9
				USD	**8300.92**

D. Chemicals for kits /Science lab for Chemistry and Biology

N0	**Required Item**	**Specification**	**Unit**	**Required quantity**	**Estimated Unit Price USD**	**Estimated Total price USD**
1	POTASSIUM CHROMATE (VI)	500 g	Bottles	1	12.5	12.5
2	POTASSIUM HYDROXIDE	500 g	Bottles	1	5.2	5.2
3	POTASSIUM THIOCYANATE	500 g	Bottles	1	12.5	12.5
4	POTASSIUM IODITE	500 g	Bottles	1	77.06	77.06
5	POTASSIUM MANGANATE (VII) POTASSIUM PERMANGANANTE	500 g	Bottles	1	4.15	4.15

6	SODIUM SULPHITE ANHYDROUS (SODIUM SULPHATE) (IV)	500 g	Bottles	1	3.75	3.75
7	SODIUM CARBONATE ANHYDROUS	500 g	Bottles	1	13.53	13.53
8	SODIUM HYDROXIDE PELLETS	500 g	Bottles	1	3.75	3.75
9	SODIUM SULPHATE ANHYDROUS	500 g	Bottles	2	2.92	5.84
10	SODIUM CHLORIDE	500 g	Bottles	1	2.09	2.09
11	SODIUM THIOSULPHATE $5H_2O$	500 g	Bottles	1	3.62	3.62
12	SODIUM NITRITE (SODIUM NITRATE III)	500 g	Bottles	1	5.2	5.2
13	SODIUM NITRATE	500 g	Bottles	1	4.15	4.15
14	CALCIUM CHLORIDE DRY, GRAIN FINE	500 g	Bottles	1	4.15	4.15
15	CALCIUM CHLORIDE LUMP, SUITABLE AS DRYING AGENT	500 g	Bottles	1	3.79	3.79
16	CALCIUM CARBONATE REAGENT	500 g	Bottles	1	2.92	2.92
17	MAGNESIUM CARBONATE	500 g	Bottles	1	8.33	8.33
18	MAGNESIUM OXIDE HEAVY REAGENT	500 g	Bottles	2	7.29	14.58
19	MAGNESIUM TURNINGS	100g	Bottles	5	24.99	124.95
20	MAGNESIUM RIBON	25g	Rolls	5	1.46	7.3
21	ALMINUM POWDER, FINE	100g	Bottles	5	2.09	10.45
22	ALUMINUM CHLORIDE $AlCl_3.6H_2O$	500 g	Bottles	1	12.5	12.5

23	ALUMINUM OXIDE REAGENT, NEUTRAL	500g	Bottles	1	3.34	3.34
24	ZINC, GRANULATED COMMERCIAL	500 g	Bottles	1	12.5	12.5
25	ZINC POWDER	500 g	Bottles	1	8.33	8.33
26	ZINC CARBONATE REAGENT	500 g	Bottles	1	6.25	6.25
27	ZINC NITRATE $6H_2O$ CRYSTALLINE REAGENT	500 g	Bottles	1	8.33	8.33
28	ZINC OXIDE REAGENT	500 g	Bottles	1	10.42	10.42
29	SILICA GEL, SELF-INDICATING BLUE	500 g	Bottles	1	5.2	5.2
30	ZINC SULPHATE $7H_2O$ REAGENT	500 g	Bottles	1	3.13	3.13
31	IRON FILINGS COARSE	500 g	Bottles	1	2.09	2.09
32	IRON FILINGS FINE	500 g	Bottles	1	2.09	2.09
33	IRON (III) SULPHATE HYDRATED	500 g	Bottles	1	7.08	7.08
34	LEAD (IV) OXIDE (LEAD DIOXIDE)	500 g	Bottles	1	14.58	14.58
35	LEAD (II) CARBONATE (BASIC)	500 g	Bottles	1	12.5	12.5
36	LEAD (II) NITRATE REAGENT	500 g	Bottles	1	5.86	5.86
37	LEAD (II) CHLORIDE	500 g	Bottles	1	12.5	12.5
38	LEAD (II) OXIDE REAGENT RED	500 g	Bottles	1	6.25	6.25
39	COPPER (I) CHLORIDE REAGENT	500g	Bottles	1	31.25	31.25
40	COPPER (I) OXIDE	500g	Bottles	1	31.25	31.25

41	COPPER (II) SULPHATE 5 HYDRATE (CUPRIC SULPHATE)	500g	Bottles	1	5.2	5.2
42	COPPER FOIL	500 g	Bottles	1	20.83	20.83
43	COPPER MILLINGS (TURNING)	500 g	Bottles	1	16.66	16.66
44	COPPER (II) SULPHATE -5- WATER COMMERCIAL CUPRIC SULPHATE	500g	Bottles	1	5.2	5.2
45	COPPER POWDER FINE	500g	Bottles	1	16.66	16.66
46	SILVER NITRATE REAGENT	25 g	Bottles	2	27.08	54.16
47	BARIUM CHLORIDE 2H2O REAGENT	500g	Bottles	1	3.75	3.75
48	MANGANESE (IV) OXIDE (MANGANESE DIOXIDE)	500g	Bottles	1	4.17	4.17
49	MANGANESE (II) CHLORIDE $4H_2O$	500g	Bottles	1	7.49	7.49
50	AMMONIUM FERROUS SULPHATE 6H2O A.R ANALYTICAL REAGENT	500g	Bottles	1	4.59	4.59
51	AMMONIUM CHLORIDE REAGENT	500g	Bottles	1	3.34	3.34
52	AMMONIUM CARBONATE REAGENT	500g	Bottles	1	4.99	4.99
53	AMMONIA HYDROXIDE	2.5l	Bottles	1	12.5	12.5
54	HYDROGEN PEROXIDE, 100 VOL.	2l	Bottles	1	11.67	11.67
55	PHOSPHOROUS, RED (PHOSPHOROUS AMORPHOUS)	50 g	Bottles	1	5.2	5.2
56	SULPHUR A.R	500g	Bottles	1	0.37	0.37

57	DIMETHYL BENZENE (XYLENE) SURFUL FREE	1L	Bottles	1	10.42	10.42
58	IODINE RESUBLIMED REAGENT	100 g	Bottles	2	10.42	20.84
59	UNIVERSAL INDICATOR SOLUTION, INCLUDING COLOUR SCALE pH 1 TO 14	125 ml	Bottles	2	1.88 0	3.76 0
60	HYDROCHLORIC ACID COMMERCIAL RC	2.5 L	Bottles	1	18.75	18.75
61	NITRIC ACID REAGENT 69% W/W HNO_3	2.5 L	Bottles	1	18.75	18.75
62	ETHANEDIOIC ACID $2H_2O$ REAGENT (OXALIC ACID)	500 g	Bottles	2	5.2	10.4
63	ETHANOL ABSOLUTE	1 L	Bottles	1	4.99	4.99
64	BUTAN - 1 - OL REAGENT (N- BUTYL ALCOHOL)	1L	Bottles	1	10.42	10.42
65	TRICHLOROMETHANE REAGENT (CHLOROFORM)	1L	Bottles	1	7.91	7.91
66	FORMALIN 40% W/V SOLUTION FORMALDEHYDE IN METHANOL	1L	Bottles	1	5.2	5.2
67	STARCH 2% W/V SOLUTION 6.58	1L	Bottles	1	3.34	3.34
68	FEHLING'S SOLUTION N0.1 COPPER	1 L	Bottles	1	8.33	8.33
69	FEHLING'S SOLUTION N0.2 (ALKALINE TARTRATE)	1 L	Bottles	1	8.33	8.33
70	PHENOL CHRYSTALS RAGENT (CARBOLIC ACID)	500 g	Bottles	1	8.33	8.33

71	AGAR POWDER	500g	Bottles	1	20.83	20.83
72	BENEDICTS SOLUTION	500 ml	Bottles	2	2.5	5
73	IODINE SOLUTION 1% IN POTASSIUM IODIDE (AQUEOUS)	500 ml	Bottles	2	3.34	6.68
74	L- ASCORBIC ACID (VITAMIN C) POWDER	100 g	Bottles	2	4.8	9.6
75	SODIUM HYDROGENCARBONATE REAGENT (SODIUM BICARBONATE)	500 g	Bottles	1	1.25	1.25
76	BROMOTYMOL BLUE DRY	5 g	Bottles	2	5.2	10.4
77	CALCIUM HYDROXIDE COMMERCIAL	500 g	Bottles	1	2.09	2.09
78	METHYL ORANGE SENSITIVE	25g	Bottles	4	2.92	11.68
79	MILLON'S REAGENT	125 ml	Bottles	2	3.34	6.68
80	PHOSPHORIC ACID (ORTHOPHOSPHORIC ACID)	1L	Bottles	1	18.75	18.75
81	POTASSIUM HEXACYANOFERRATE (II) 3H2O REAGENT (POTASSIUM FERROCYANIDE)	500g	Bottles	1	13.53	13.53
82	POTASSIUM HEXACYANOFERRATE (III) REAGENT (POTASSIUM FERRIYANIDE)	500 g	Bottles	1	11.67	11.67
83	PHENOLPHTALEIN SOLUTION, 1%	500ml	Bottles	2	2.92	5.84
84	LITMUS SOLUTION BLUE	500ml	Bottles	2	6.25	12.5
85	LITMUS SOLUTION RED	500ml	Bottles	2	6.25	12.5
86	LITMUS RED BOX PACK OF 10 BOOKS, 100 STRIPS	1 Box	boxes	10	0.49	4.9

87	LITMUS BLUE BOX PACK OF 10 BOOKS, 100 STRIPS	1 Box	boxes	10	0.49	4.9
88	LEAD FOIL	100g	Roll	2	4.15	8.3
89	NAPHTHALENE POWDER	500 g	Bottles	1	2.92	2.92
90	STARCH SOLUBLE	500 g	Bottles	1	2.92	2.92
91	ACETIC ACID	2.5l	Bottles	1	12.5	12.5
92	2,4-DINITROPHENYL HYDRAZINE OR BRADY'S REAGENT	500ml	Bottles	1	3.58	3.58
93	AMMONIA SOLUTION 25%	2.5l	Bottles	1	12.5	12.5
94	CALCIUM OXIDE	500g	Bottles	1	2.09	2.09
95	ACETONE	2.5l	Bottles	1	12.5	12.5
96	ETHANAL	500ml	Bottles	1	6.25	6.25
97	SULPHURIC ACID 98%	2.5l	Bottles	1	18.75	18.75
98	ACETO CARMINE: STAINS FOR PREPARING SLIDES TO SHOW MITOSIS (FOR CHROMOSOMES IN FRESH TISSUE)	100ml	Bottles	1	1.76	1.76
99	METHYLATED SPIRIT (FOR EXTRACTION OF CHLOROPHYLL)	1L	Bottles	1	8.33	8.33
100	TOLUIDINE BLUE STAINS FOR PREPARING SLIDES TO SHOW MITOSIS	10g	Bottles	1	2.09	2.09
101	BUFFER SOLUTION pH 4	500 ml	Bottles	1	3.34	3.34

102	BUFFER SOLUTION pH 7	500 ml	Bottles	1	3.34	3.34
103	BUFFER SOLUTION pH 10	500 ml	Bottles	1	3.34	3.34
104	SILICA GEL FOR COLUMN CHROMATOGRAPHY, SIZE 0.040-0.063 mm	500g	Bottles	2	9.8	19.6
					USD	**1124.72**

E. Chemicals for kits /Science lab for Chemistry and Biology

N0	**Required Item**	**Specification**	**Unit**	**Required quantity**	**Estimated Unit Price USD**	**Estimated Total price USD**
1	POTASSIUM CHROMATE (VI)	500 g	Bottles	1	12.5	12.5
2	POTASSIUM HYDROXIDE	500 g	Bottles	1	5.2	5.2
3	POTASSIUM THIOCYANATE	500 g	Bottles	1	12.5	12.5
4	POTASSIUM IODITE	500 g	Bottles	1	77.06	77.06
5	POTASSIUM MANGANATE (VII) POTASSIUM PERMANGANANTE	500 g	Bottles	1	4.15	4.15
6	SODIUM SULPHITE ANHYDROUS (SODIUM SULPHATE) (IV)	500 g	Bottles	1	3.75	3.75
7	SODIUM CARBONATE ANHYDROUS	500 g	Bottles	1	13.53	13.53
8	SODIUM HYDROXIDE PELLETS	500 g	Bottles	1	3.75	3.75
9	SODIUM SULPHATE ANHYDROUS	500 g	Bottles	2	2.92	5.84

10	SODIUM CHLORIDE	500 g	Bottles	1	2.09	2.09
11	SODIUM THIOSULPHATE $5H_2O$	500 g	Bottles	1	3.62	3.62
12	SODIUM NITRITE (SODIUM NITRATE III)	500 g	Bottles	1	5.2	5.2
13	SODIUM NITRATE	500 g	Bottles	1	4.15	4.15
14	CALCIUM CHLORIDE DRY, GRAIN FINE	500 g	Bottles	1	4.15	4.15
15	CALCIUM CHLORIDE LUMP, SUITABLE AS DRYING AGENT	500 g	Bottles	1	3.79	3.79
16	CALCIUM CARBONATE REAGENT	500 g	Bottles	1	2.92	2.92
17	MAGNESIUM CARBONATE	500 g	Bottles	1	8.33	8.33
18	MAGNESIUM OXIDE HEAVY REAGENT	500 g	Bottles	2	7.29	14.58
19	MAGNESIUM TURNINGS	100g	Bottles	5	24.99	124.95
20	MAGNESIUM RIBON	25g	Rolls	5	1.46	7.3
21	ALMINUM POWDER, FINE	100g	Bottles	5	2.09	10.45
22	ALUMINUM CHLORIDE $AlCl_3.6H_2O$	500 g	Bottles	1	12.5	12.5
23	ALUMINUM OXIDE REAGENT, NEUTRAL	500g	Bottles	1	3.34	3.34
24	ZINC, GRANULATED COMMERCIAL	500 g	Bottles	1	12.5	12.5
25	ZINC POWDER	500 g	Bottles	1	8.33	8.33

26	ZINC CARBONATE REAGENT	500 g	Bottles	1	6.25	6.25
27	ZINC NITRATE $6H_2O$ CRYSTALLINE REAGENT	500 g	Bottles	1	8.33	8.33
28	ZINC OXIDE REAGENT	500 g	Bottles	1	10.42	10.42
29	SILICA GEL, SELF-INDICATING BLUE	500 g	Bottles	1	5.2	5.2
30	ZINC SULPHATE $7H_2O$ REAGENT	500 g	Bottles	1	3.13	3.13
31	IRON FILINGS COARSE	500 g	Bottles	1	2.09	2.09
32	IRON FILINGS FINE	500 g	Bottles	1	2.09	2.09
33	IRON (III) SULPHATE HYDRATED	500 g	Bottles	1	7.08	7.08
34	LEAD (IV) OXIDE (LEAD DIOXIDE)	500 g	Bottles	1	14.58	14.58
35	LEAD (II) CARBONATE (BASIC)	500 g	Bottles	1	12.5	12.5
36	LEAD (II) NITRATE REAGENT	500 g	Bottles	1	5.86	5.86
37	LEAD (II) CHLORIDE	500 g	Bottles	1	12.5	12.5
38	LEAD (II) OXIDE REAGENT RED	500 g	Bottles	1	6.25	6.25
39	COPPER (I) CHLORIDE REAGENT	500g	Bottles	1	31.25	31.25
40	COPPER (I) OXIDE	500g	Bottles	1	31.25	31.25
41	COPPER (II) SULPHATE 5 HYDRATE (CUPRIC SULPHATE)	500g	Bottles	1	5.2	5.2
42	COPPER FOIL	500 g	Bottles	1	20.83	20.83

43	COPPER MILLINGS (TURNING)	500 g	Bottles	1	16.66	16.66
44	COPPER (II) SULPHATE -5- WATER COMMERCIAL CUPRIC SULPHATE	500g	Bottles	1	5.2	5.2
45	COPPER POWDER FINE	500g	Bottles	1	16.66	16.66
46	SILVER NITRATE REAGENT	25 g	Bottles	2	27.08	54.16
47	BARIUM CHLORIDE 2H2O REAGENT	500g	Bottles	1	3.75	3.75
48	MANGANESE (IV) OXIDE (MANGANESE DIOXIDE)	500g	Bottles	1	4.17	4.17
49	MANGANESE (II) CHLORIDE $4H_2O$	500g	Bottles	1	7.49	7.49
50	AMMONIUM FERROUS SULPHATE 6H2O A.R ANALYTICAL REAGENT	500g	Bottles	1	4.59	4.59
51	AMMONIUM CHLORIDE REAGENT	500g	Bottles	1	3.34	3.34
52	AMMONIUM CARBONATE REAGENT	500g	Bottles	1	4.99	4.99
53	AMMONIA HYDROXIDE	2.5l	Bottles	1	12.5	12.5
54	HYDROGEN PEROXIDE, 100 VOL.	2l	Bottles	1	11.67	11.67
55	PHOSPHOROUS, RED (PHOSPHOROUS AMORPHOUS)	50 g	Bottles	1	5.2	5.2
56	SULPHUR A.R	500g	Bottles	1	0.37	0.37
57	DIMETHYL BENZENE (XYLENE) SURFUL FREE	1L	Bottles	1	10.42	10.42
58	IODINE RESUBLIMED REAGENT	100 g	Bottles	2	10.42	20.84

	UNIVERSAL INDICATOR SOLUTION,				1.88	3.76
59	INCLUDING COLOUR SCALE pH 1 TO 14	125 ml	Bottles	2	0	0
60	HYDROCHLORIC ACID COMMERCIAL RC	2.5 L	Bottles	1	18.75	18.75
61	NITRIC ACID REAGENT 69% W/W HNO_3	2.5 L	Bottles	1	18.75	18.75
62	ETHANEDIOIC ACID $2H_2O$ REAGENT (OXALIC ACID)	500 g	Bottles	2	5.2	10.4
63	ETHANOL ABSOLUTE	1 L	Bottles	1	4.99	4.99
64	BUTAN - 1 - OL REAGENT (N- BUTYL ALCOHOL)	1L	Bottles	1	10.42	10.42
65	TRICHLOROMETHANE REAGENT (CHLOROFORM)	1L	Bottles	1	7.91	7.91
66	FORMALIN 40% W/V SOLUTION FORMALDEHYDE IN METHANOL	1L	Bottles	1	5.2	5.2
67	STARCH 2% W/V SOLUTION 6.58	1L	Bottles	1	3.34	3.34
68	FEHLING'S SOLUTION N0.1 COPPER	1 L	Bottles	1	8.33	8.33
69	FEHLING'S SOLUTION N0.2 (ALKALINE TARTRATE)	1 L	Bottles	1	8.33	8.33
70	PHENOL CHRYSTALS RAGENT (CARBOLIC ACID)	500 g	Bottles	1	8.33	8.33

71	AGAR POWDER	500g	Bottles	1	20.83	20.83
72	BENEDICTS SOLUTION	500 ml	Bottles	2	2.5	5
73	IODINE SOLUTION 1% IN POTASSIUM IODIDE (AQUEOUS)	500 ml	Bottles	2	3.34	6.68
74	L- ASCORBIC ACID (VITAMIN C) POWDER	100 g	Bottles	2	4.8	9.6
75	SODIUM HYDROGENCARBONATE REAGENT (SODIUM BICARBONATE)	500 g	Bottles	1	1.25	1.25
76	BROMOTYMOL BLUE DRY	5 g	Bottles	2	5.2	10.4
77	CALCIUM HYDROXIDE COMMERCIAL	500 g	Bottles	1	2.09	2.09
78	METHYL ORANGE SENSITIVE	25g	Bottles	4	2.92	11.68
79	MILLON'S REAGENT	125 ml	Bottles	2	3.34	6.68
80	PHOSPHORIC ACID (ORTHOPHOSPHORIC ACID)	1L	Bottles	1	18.75	18.75
81	POTASSIUM HEXACYANOFERRATE (II) 3H2O REAGENT (POTASSIUM FERROCYANIDE)	500g	Bottles	1	13.53	13.53
82	POTASSIUM HEXACYANOFERRATE (III) REAGENT (POTASSIUM FERRIYANIDE)	500 g	Bottles	1	11.67	11.67
83	PHENOLPHTALEIN SOLUTION, 1%	500ml	Bottles	2	2.92	5.84

84	LITMUS SOLUTION BLUE	500ml	Bottles	2	6.25	12.5
85	LITMUS SOLUTION RED	500ml	Bottles	2	6.25	12.5
86	LITMUS RED BOX PACK OF 10 BOOKS, 100 STRIPS	1 Box	boxes	10	0.49	4.9
87	LITMUS BLUE BOX PACK OF 10 BOOKS, 100 STRIPS	1 Box	boxes	10	0.49	4.9
88	LEAD FOIL	100g	Roll	2	4.15	8.3
89	NAPHTHALENE POWDER	500 g	Bottles	1	2.92	2.92
90	STARCH SOLUBLE	500 g	Bottles	1	2.92	2.92
91	ACETIC ACID	2.5l	Bottles	1	12.5	12.5
92	2,4-DINITROPHENYL HYDRAZINE OR BRADY'S REAGENT	500ml	Bottles	1	3.58	3.58
93	AMMONIA SOLUTION 25%	2.5l	Bottles	1	12.5	12.5
94	CALCIUM OXIDE	500g	Bottles	1	2.09	2.09
95	ACETONE	2.5l	Bottles	1	12.5	12.5
96	ETHANAL	500ml	Bottles	1	6.25	6.25
97	SULPHURIC ACID 98%	2.5l	Bottles	1	18.75	18.75
98	ACETO CARMINE: STAINS FOR PREPARING SLIDES TO SHOW MITOSIS (FOR CHROMOSOMES IN FRESH TISSUE)	100ml	Bottles	1	1.76	1.76

99	METHYLATED SPIRIT (FOR EXTRACTION OF CHLOROPHYLL)	1L	Bottles	1	8.33	8.33
100	TOLUIDINE BLUE STAINS FOR PREPARING SLIDES TO SHOW MITOSIS	10g	Bottles	1	2.09	2.09
101	BUFFER SOLUTION pH 4	500 ml	Bottles	1	3.34	3.34
102	BUFFER SOLUTION pH 7	500 ml	Bottles	1	3.34	3.34
103	BUFFER SOLUTION pH 10	500 ml	Bottles	1	3.34	3.34
104	SILICA GEL FOR COLUMN CHROMATOGRAPHY, SIZE 0.040-0.063 mm	500g	Bottles	2	9.8	19.6
					USD	**1124.72**
105	UNESCO Micro-Science(Physics, Biology & Chemistry)					

F. List of items and kits for Software skills development lab

*No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1	Develop software development syllabus.	Develop syllabus for software development in Java, Python, C#, C++, PHP, Javascript….	3	5,000	15,000
2	Projectos	PROJECTOR EPSON EB-E10	1	870	870

3	Whiteboard projection screen	Electric Projector Screen 180”X180”	1	200	200
4	Testing servers	PowerEdge T150 Tower Server, Intel® Pentium® G6405T processor, Optional Operating System, 8GB Memory, 1TB Hard Drive	2	1,300	2,600
5	Cloud Hosting space	2 Intel E5-2670v3 12 Core/24 Thread 2.3Ghz 30Mb Cache Processors 512 GB RAM Internal drives - 256GB Samsung SSD	1	1,500	1,500
6	HDMI Cable	20 Meters HDMI Cable	1	30	30
Grand Total/USD					**20,200**

G. List of items and kits for 4IR Technologies (including Robotics, AI, IoT, Drones etc.)

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1	VEX competition robots	VEXnet System Bundle	10	800	8,000
2	Marty the Robot V2	Marty the Robot V2 – the walking, dancing, coding companion	10	520	5,200
3	mBot	mBot is a STEM coding robot for beginners	20	90	1,800
4	Lego Mindstorm Ev3	The LEGO MINDSTORMS EV3 robot revolution	10	600	6,000
5	LEGO Education WeDo 2.0	LEGO Education WeDo 2.0 Core Set	10	250	2,500
Grand Total/USD					23,500

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
Laboratory Tools/Equipments					
1	power supply	220v ac variable (output :0-12v 5A Max)	15	96.0	1,440.2
2	power adapters	12v 2A	45	7.7	345.7
3	Screws Driver	set	20	9.6	192.0
4	Digital Multimeter		45	14.4	648.1
5	rechargeable batteries		200	81.6	16,322.6
6	batteries chargers 4cells		50	10.6	528.1
7	Solderless Breadboard		150	3.8	576.1
Wires and Connectors					
1	8 cores wires		10	62.4	624.1
2	Wire-to-Board Connectors		1,000	1.9	1,920.3
3	Female -Female Jumper wires	12v 2A	500	1.4	720.1
Computer and Accessories					

1	**Computer**	**core i3 @ 2.1GHZ processor and above min Storage 500GB**	**50**	**432.1**	**21,603.5**
2	**UPS AVI**	**220V@ 650W**	**50**	**48.0**	**2,400.4**
3	**Flash disc**	**8GB**	**10**	**4.8**	**48.0**
4	**Antivirus and license**		**26**	**24.0**	**624.1**
5	**Multi Socket**	**5 ports (5m)**	**40**	**14.4**	**576.1**
6	**Projector**		**2**	**672.1**	**1,344.2**
Display Devices					
1	**LED DISPLAY**	**7 SEGMENT COMMON CATHODE**	**100**	**1.0**	**96.0**
2	**DISPLAY**	**WITH I2C (16×2) LCD**	**100**	**9.6**	**960.2**
5	**LED**	**12V 5W (1mm)**	**16**	**4.8**	**76.8**
6	**LED**	**5V 5mm**	**500**	**0.5**	**240.0**
7	**5MM STRAW HAT RGB RED GREEN BLUE LIGHT EMITTING LED LAMP SLOW FLASHING**		**200**	**0.5**	**96.0**
Radio Communication Modules					
1	**Xbee**		**100**	**62.4**	**6,241.0**

2	**Development Board**	**LoRa32u4 II**	**100**	**61.4**	**6,145.0**
3	**Bluetooth Module**		**50**	**7.5**	**374.5**
4	**Bluetooth XBee Shield**	**V03 Module Wireless Control**	**100**	**6.2**	**624.1**
5	**XBee Module**	**with Wire Antenna**	**100**	**74.9**	**7,489.2**
CAR Robot Parts					
1	**Plastic Tire**	**Wheel with DC Motor**	**200**	**3.4**	**672.1**
2	**Motor Drive Board**	**Shield Expansion L293D**	**100**	**6.2**	**624.1**
3	**Bluetooth Module**		**100**	**7.5**	**748.9**
4	**Ultrasonic Module Sensor**	**– HC-SR04**	**100**	**6.2**	**624.1**
5	**Male -Male Jumper Jumper wires**		**500**	**1.4**	**720.1**
6	**Male-Female Jumper Jumper wires**		**500**	**1.4**	**720.1**
7	**Charger Li-ion Lithium Battery Protection Board**	**3S 12V 18650 10A BMS**	**500**	**7.5**	**3,744.6**
8	**nuts and bolts**		**2,000**	**0.1**	**288.0**
9	**PulseMotor Speed Regulator Controller**	**12V-36V Width PWM DC**	**100**	**6.2**	**624.1**

		12V 24V 3A			
10	**wooden Robot Frame**		**100**	**8.2**	**816.1**
11	**1 METER LONG ALLIGATOR CLIP LARGE WIRE TEST LEAD**		**200**	**1.9**	**384.1**
12	**MINI MICRO CONNECTOR MALE FEMALE PLUG WITH WIRES CABLES SOCKET CONNECTORS**	**JST PH-2.0**	**1,000**	**2.4**	**2,400.4**
13	**40 PIN 1×40 SINGLE ROW MALE AND FEMALE 2.54 BREAKABLE PIN HEADER CONNECTOR**		**150**	**0.2**	**36.0**
14	**arduino 45 in 1 Sensors Modules Starter Kit**		**100**	**45.0**	**4,500.0**
15	**2 pin wire connectors for pcb**		**500**	**0.4**	**216.0**
Analogue and Digital Components					
1	**Resistors (Different Values)**		**10,000**	**0.1**	**1,440.2**
2	**VOLTAGE REGULATOR IC 7905**		**100**	**1.0**	**96.0**
3	**IC CD40047**		**150**	**1.4**	**216.0**
4	**IC CD 4027**		**150**	**1.4**	**216.0**
5	**IC CD 4013**		**150**	**1.4**	**216.0**
6	**IC CD 4001**		**150**	**1.4**	**216.0**

7	**IC NE 555**		**150**	**1.4**	**216.0**
8	**Ceramic capacitor 100 nF**		**150**	**1.4**	**216.0**
9	**IC NE555 Multivibrator**		**150**	**1.4**	**216.0**
10	**IC CD 4047 multivibrator**		**150**	**1.4**	**216.0**
11	**AND gates (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
12	**NAND gates (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
13	**NOR gates (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
14	**OR gates (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
15	**XNOR (exclusive NOR) gates (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
16	**XOR (exclusive OR) gates (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
17	**JK Flipflop (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
18	**counters (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
19	**Decoder (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**

20	**Encoder (Anny TTL or CMOS Available)**		**150**	**1.4**	**216.0**
21	**220v to 5V DC 3A Power Supply Charger**		**150**	**15.4**	**2,304.4**
22	**5MM 5v LED**		**150**	**0.6**	**86.4**
23	**470 Ohms Resistors**		**150**	**0.5**	**72.0**
24	**120 Uf /16v Capacitor**		**150**	**0.5**	**72.0**
25	**100nF**		**150**	**0.2**	**28.8**
26	**100k Ohms**		**150**	**0.3**	**43.2**
27	**50k Ohms Potentiometer**		**150**	**2.4**	**360.1**
28	**100nF variable Capacitor**		**150**	**1.4**	**216.0**
29	**0.02 mm copper wire**		**150**	**28.8**	**4,320.7**
30	**Mini PCB board**		**150**	**1.4**	**216.0**
31	**ZY-208 Solderless Breadboard**		**150**	**33.6**	**5,040.8**
32	**Jumper Cable Kit**		**150**	**6.2**	**936.1**
33	**Low power (High speed) NPN Transistor**		**150**	**1.0**	**144.0**
34	**Low power (High speed) PN PTransistor**		**150**	**0.1**	**14.4**
35	**High power (High speed) NPN Transistor**		**150**	**2.4**	**360.1**

36	**Highpower (High speed) PN PTransistor**		**150**	**2.4**	**360.1**
37	**N channel Mosfet**		**150**	**2.4**	**360.1**
38	**P channel Mosfet**		**150**	**2.4**	**360.1**
39	**Research component (Will be specified by learner after understanding electronics in there projects)**		**150**	**144.0**	**21,603.5**
40	**SN74HC595N 8 Bit Shift Register**		**150**	**1.9**	**288.0**
41	**CA3130 Single Operational Amplifier**		**150**	**1.9**	**288.0**
42	**L293D Quadruple Half-H Driver**		**150**	**2.9**	**432.1**
43	**Anny Available crystal Oscillator**		**150**	**2.9**	**432.1**
44	**TX-2B IC OR equivalence**		**150**	**10.1**	**1,512.2**
45	**RX-2B IC OR equivalence**		**150**	**10.1**	**1,512.2**
Drone Parts					
1	**Aero sim Drone simulator + Licence Pro**		**50**	**480.1**	**24,003.8**
2	**30A Speed Controller ESC for RC Brushless Motor Airplane Quadcopter Drones 3.5mm Banana**		**50**	**38.4**	**1,920.3**

3	**F450 Quadcopter Kit - DIY Quadcopter - With Motors, Frame, Controller**		**50**	**62.4**	**3,120.5**
4	**Standard Prop**		**100**	**14.4**	**1,440.2**
5	**30A Brushless Motor ESC**		**50**	**19.2**	**960.2**
6	**Gemfan 8045 8x4.5 8 Inch Carbon Nylon CW/CCW Propeller For DJI RC Quadcopter**		**100**	**7.7**	**768.1**
7	**KK2.1.5 LCD Flight Control Board V1.17S1PRO 6050MPU 644PA for RC Airplane FPV Racing Drone**		**50**	**28.8**	**1,440.2**
8	**4X Racerstar Racing Edition 2212 BR2212 980KV 2-4S Brushless Motor For 350 380 400 RC Drone FPV Racing**		**50**	**33.6**	**1,680.3**
9	**FlySky FS-i6 i6 2.4G 6CH AFHDS RC Radio Transmitter Without Receiver for FPV RC Drone Engineering Vehicle Boat Robot - With Color Box Mode 2 (Left Hand Throttle)**		**50**	**149.8**	**7,489.2**
10	**14.8V 1800mAh 65C 4S Lipo Battery XT60 Plug For RC FPV Racing Drone**		**50**	**24.0**	**1,200.2**
11	**10kg Servo motors**		**100**	**9.6**	**960.2**

Laboratory Extra tools					
1	**Drone Simulation Kit(Aero Sim)**		**4**	**384.1**	**1,536.2**
1	**Nichrome wire**		**2**	**52.8**	**105.6**
2	**BOSCH Dremel 4000 Rotary Tool 175 W Multi Tool Kit with 3 Attachment 36 Accessories Variable Speed 5000-35000 RPM Power Tools**		**3**	**269.6**	**808.7**
3	**Wireless Laser Engraver Cutter Wood Cutting Engraving Machine Router, ZBAITU 81X46CM 80W Air Assisted Laser Module**		**1**	**478.0**	**478.0**
4	**220v to 12v/20A Transformer**		**1**	**28.8**	**28.8**
5	**Metal Electric Soldering Iron Stand Holder**		**8**	**4.8**	**38.4**
6	**Soldering Iron 60W**		**8**	**4.5**	**36.3**
7	**Soldering Iron tip cleaner**		**4**	**9.6**	**38.4**
8	**Soldering Iron Replacement Solder Tip Welding Cleaning Sponge Pads**		**8**	**1.4**	**11.5**
13	**Educational Drone**		**4**	**408.9**	**1,635.4**
PROJECT NO 1/INTRODUCTION TO ELECTRICITY(DC AND AC)					
1	**One way switches(Electric)**		**24**	**2.9**	**69.1**
2	**Two way switches (Electric)**		**16**	**3.4**	**53.8**

3	**posh buttons (Electric)**		**16**	**1.0**	**15.4**
4	**protection Diodes**		**32**	**0.5**	**15.4**
5	**LED 12V Strip (1m)**		**8**	**5.8**	**46.1**
6	**50CX70 CM plywood**		**8**	**2.4**	**19.2**
7	**wires 1.5mm**		**8**	**24.0**	**192.0**
8	**socket**		**24**	**1.4**	**34.6**
9	**220v 9v LED bulbs**		**24**	**1.2**	**27.7**
10	**contactors**		**8**	**23.0**	**184.3**
11	**12v 2 way relays**		**24**	**2.4**	**57.6**
12	**220v timer**		**24**	**15.4**	**368.7**
13	**22ov /12v 3A power adapter**		**8**	**7.7**	**61.4**
14	**220v 300w single phase motor**		**8**	**19.2**	**153.6**
PROJECT NO 2/ Battery Assembling					
1	**lithium ion battery 18650**		**32**	**12.5**	**399.4**
2	**Battery Battery shrapnel AA or AAA battery spring 5 No. positive**		**32**	**1.0**	**30.7**
3	**YR1030+ Battery Internal Resistance/Voltage Test Instrument 0-45V COM37**		**4**	**115.2**	**460.9**
4	**PVC pipe 110MM**		**1**	**11.5**	**11.5**

5	**Plastic Battery Storage Case Box Holder 4 X AA**		**8**	**3.8**	**30.7**
6	**New EU Li-ion Battery Charger For 3.7V 18650**		**8**	**9.6**	**76.8**
PROJECT NO 3/ Analogue and Digital Circuits					
1	**IC NE555 Multivibrator**		**16**	**1.4**	**23.0**
2	**IC CD 4047 multivibrator**		**16**	**1.4**	**23.0**
3	**AND gates (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
4	**NAND gates (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
5	**NOR gates (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
6	**OR gates (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
7	**XNOR (exclusive NOR) gates (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
8	**XOR (exclusive OR) gates (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
9	**JK Flip Flop (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
10	**counters (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**

11	**Decoder (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
12	**Encoder (Anny TTL or CMOS Available)**		**16**	**1.4**	**23.0**
13	**220v to 5V DC 3A Power Supply Charger**		**16**	**15.4**	**245.8**
14	**5MM 5v LED**		**40**	**0.6**	**23.0**
15	**470 Ohms Resistors**		**40**	**0.5**	**19.2**
13	**120 Uf /16v Capacitor**		**16**	**0.5**	**7.7**
14	**100nF**		**40**	**0.2**	**7.7**
15	**100k Ohms**		**40**	**0.3**	**11.5**
16	**50k Ohms Potentiometer**		**16**	**2.4**	**38.4**
17	**100nF variable Capacitor**		**16**	**1.4**	**23.0**
18	**0.02 mm copper wire**		**1**	**28.8**	**28.8**
19	**Mini PCB board**		**64**	**1.4**	**92.2**
20	**ZY-208 Solderless Breadboard**		**8**	**33.6**	**268.8**
22	**Jumper Cable Kit**		**8**	**6.2**	**49.9**
23	**Low power (High speed) NPN Transistor**		**80**	**1.0**	**76.8**
24	**Low power (High speed) PN PTransistor**		**80**	**0.1**	**7.7**

25	**High power (High speed) NPN Transistor**		**80**	**2.4**	**192.0**
26	**Highpower (High speed) PN PTransistor**		**80**	**2.4**	**192.0**
27	**N channel Mosfet**		**48**	**2.4**	**115.2**
28	**P channel Mosfet**		**48**	**2.4**	**115.2**
29	**Research component (Will be specified by learner after understanding electronics in there projects)**		**8**	**144.0**	**1,152.2**
30	**SN74HC595N 8 Bit Shift Register**		**16**	**1.9**	**30.7**
31	**CA3130 Single Operational Amplifier**		**16**	**1.9**	**30.7**
32	**L293D Quadruple Half-H Driver**		**16**	**2.9**	**46.1**
33	**Anny Available crystal Oscillator**		**16**	**2.9**	**46.1**
34	**TX-2B IC OR equivalence**		**16**	**10.1**	**161.3**
35	**RX-2B IC OR equivalence**		**16**	**10.1**	**161.3**
PROJECT NO 4/ Un controlled Robot car(Analogue Robot I)					
1	**Robot Car Chassis**		**8**	**8.2**	**65.3**
2	**Mini 12V Battery Backup UPS**		**8**	**39.7**	**317.2**
3	**Plastic Tire Wheel with DC Motor**		**32**	**3.2**	**101.5**

4	**3mm nut and screws**		**192**	**0.2**	**36.9**
5	**8 cores wire**		**1**	**56.6**	**56.6**
PROJECT NO 5/Electrical wired Remote controlled Robot car(Analogue Robot II)					
1	**Plastic Tire Wheel with DC Motor**		**32**	**3.2**	**101.5**
2	**PCB StripBoard Uncut Strips Single Side Board 9.7×24.5cm**		**8**	**2.9**	**23.0**
3	**9V Rechargeable Battery-450mah**		**8**	**14.4**	**115.2**
4	**12*12*5mm DIP 4 Pin Push Button**		**32**	**0.3**	**10.9**
5	**12v 2 way relays**		**24**	**2.4**	**57.6**
6	**Switch**		**8**	**0.5**	**3.8**
7	**Robot Frame**		**8**	**8.2**	**65.3**
8	**8 core WIRES**		**1**	**56.6**	**56.6**
PROJECT NO 6/Electronics PWM wired Remote controlled Robot car(Analogue Robot III)					
1	**Plastic Tire Wheel with DC Motor**		**32**	**3.2**	**101.5**
2	**PCB StripBoard Uncut Strips Single Side Board 9.7×24.5cm**		**8**	**2.9**	**23.0**
3	**9V Rechargeable Battery-450mah**		**8**	**14.4**	**115.2**
4	**555 Timer IC**		**8**	**1.4**	**11.5**
5	**1K resistors**		**8**	**0.3**	**2.3**

6	**100R resistors**		**8**	**0.3**	**2.3**
7	**L293D Quadruple Half-H Driver IC**		**8**	**1.9**	**15.4**
8	**100K -220K preset or pot**		**8**	**1.9**	**15.4**
9	**IN4148 or IN4047**		**16**	**0.3**	**4.6**
10	**10nF or 22nF capacitor**		**8**	**0.4**	**3.1**
11	**Switch**		**8**	**0.5**	**3.8**
12	**Robot Frame**		**8**	**8.2**	**65.3**
13	**8 core WIRES**		**1**	**56.6**	**56.6**
PROJECT NO 7/ Programmable devices					
1	**Arduino uno R3**		**8**	**17.0**	**136.0**
2	**Arduino Mega 2560 R3**		**8**	**29.8**	**238.1**
3	**Arduino (nano)**		**8**	**14.4**	**115.2**
4	**ATMEGA8A-PU**		**8**	**11.5**	**92.2**
5	**MINI USB Arduino Nano V3.0 ATmega328P**		**8**	**3.2**	**25.4**
6	**Solderless PCB**		**8**	**0.2**	**1.5**
PROJECT NO 8/ Tasked Programmable Robot I					
1	**rotational front wheel**		**8**	**1.4**	**11.5**
2	**Plastic Tire Wheel with DC Motor**		**16**	**3.2**	**50.8**

	IR Line Tracking Sensor SEN55		**16**	**4.0**	**63.4**
	L293D Quadruple Half-H Driver		**16**	**2.9**	**46.1**
3	**KF128 2.54mm PCB Mini Screw Terminal Blocks Connector**		**16**	**3.8**	**61.4**
5	**Robot Frame**		**8**	**8.2**	**65.3**
6	**PCB StripBoard Uncut Strips Single Side Board 9.7×24.5cm**		**8**	**2.9**	**23.0**
PROJECT NO 9/ Tasked Programmable Robot II(Intelligent sensor and IOT)					
1	**PIR Motion sensor**		**8**	**17.3**	**138.3**
2	**Arduino uno R3**		**8**	**17.0**	**136.0**
3	**SIM800C GSM GPRS Module with Bluetooth and TTS for Arduino**		**8**	**16.3**	**130.6**
4	**sirene**		**8**	**19.2**	**153.6**
5	**Relay Module**		**8**	**9.6**	**76.8**
6	**TDA2030A Amplifier Board module Voice Amplifier Single Power Supply**		**8**	**3.2**	**25.4**
7	**Serial MP3 Music Player Module AVR/ARM/PIC for arduino**		**8**	**7.7**	**61.4**
8	**2GB memory cards**		**8**	**3.8**	**30.7**
9	**12v Battery**		**8**	**14.4**	**115.2**
PROJECT NO10/ wired Programmable Remote controlled Robot Car					

1	**Arduino uno R3**		**8**	**17.0**	**136.0**
2	**Motor Drive Shield Expansion Board L293D**		**8**	**5.1**	**40.8**
3	**Push button**		**32**	**0.4**	**12.3**
4	**resustor(4.7k)**		**80**	**0.4**	**30.7**
	LED 5MM		**32**	**0.3**	**10.8**
5	**Plastic Tire Wheel with DC Motor**		**16**	**3.2**	**50.8**
PROJECT NO 11/ Programmable Radio communication Devices					
1	**LoRa32u4 II Development Board 868MHz 915MHz Lora Module**		**16**	**52.8**	**844.9**
2	**HC05 Bluetooth RF Transceiver Module**		**16**	**9.6**	**153.6**
3	**Android tablet**		**8**	**240.0**	**1,920.3**
4	**Flysky FS-i6s 2.4G 10CH AFHDS 2A RC Transmitter + FS-iA6B 6CH RC Receiver**		**8**	**52.8**	**422.5**
PROJECT NO 12/ wireless remote controlled car					
1	**Arduino uno**		**8**	**17.0**	**136.0**
2	**Motor Drive Shield Expansion Board L293D**		**8**	**5.1**	**40.8**

3	**HC05 Bluetooth RF Transceiver Module**		**8**	**7.9**	**63.4**
4	**Robot Frame**		**8**	**8.2**	**65.3**
PROJECT NO 13/ Application of All Arduino sensors					
1	**arduino 45 in 1 Sensors Modules Starter Kit**		**8**	**57.6**	**460.9**
2	**Advanced Version Starter Kit the RFID learn Suite Kit LCD 1602 for Arduino UNO R3**		**8**	**62.4**	**499.3**
PROJECT NO 14/ Final Project					
1	**Final Project Items(to be Defined by Trainees)**		**8**	**144.0**	**1,152.2**
PROJECT NO 15/ Tasked Programmable Robot III(Aerial Robotics)					
1	**Drone Simulation Kit (Aero Sim)**		**4**	**400.0**	**1,600.0**
2	**All total Drone parts**		**8**	**432.1**	**3,456.6**
3	**RCA Drone license for instructors(UAS) Pilot license**		**2**	**100.0**	**200.0**
4	**USA operator certificates**		**1**	**500.0**	**500.0**
5	**USA Registration**		**1**	**100.0**	**100.0**
6	**USA Authorization Activity**		**8**	**5.0**	**40.0**
7	**Extra cost**		**8**	**70.0**	**560.0**

Grand Total	**207,319.7**

H. List of items and kits for Mathematics lab

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1					
2					
3					
4					
.					
.					
N					
Grand Total/USD					

I. List of items and kits for Mechatronics lab

No.	Required Items	Required number	Estimated unit price/USD	Estimated Total price/USD
1	Full mechatronic system assembling with 2 stocks for a working process, operator panel, maintenance topic, with industrial PLC and augmented reality, compressor included	1	27.910,50	27.910,50
2	Full mechatronic system sorting with 2 stocks for a working process, operator panel, maintenance topic, with industrial PLC and augmented reality	1	22.482,90	22.482,90

3	Full mechatronic system processing with 2 stocks for a working process, operator panel, maintenance topic, with industrial PLC and augmented reality	1	24.232,30	24.232,30
4	Full mechatronic handling for a working process, operator panel, maintenance topic, with industrial PLC and augmented reality	1	20.492,50	20.492,50
5	Basic system on DC, AC and three phase electricity, interactive course	1	6.276,00	6.276,00
6	Basic system on electrical machines DC, three phase, interactive course	1	9.197,00	9.197,00
7	Basic system on power electronics, interactive course	1	8.761,00	8.761,00
8	Basic system on frequency converter with asynchronous three phase motor, interactive course	1	8.716,00	8.716,00
9	Basic system on control technology, digital and analog PID controller, interactive course	1	8.190,00	8.190,00
10	Basic system on industriel PLC with HMI and application simulation on the HMI, interactive course	1	4.083,80	4.083,80
11	Motor Control system with PLC and frequency converter, open-loop, interactive course	1	6.916,50	6.916,50
12	System on power electronics with asynchron three phase motor control and industrial load simulation, interactive course	1	25.211,80	25.211,80
13	Pneumatic system	1	11.978,00	11.978,00
14	Pneumatic and electropneumatic system	1	21.333,70	21.333,70
15	Hydraulic system	1	27.575,90	27.575,90

16	Hydraulic and electrohydraulic system	1	36.341,90	36.341,90
Grand Total/USD				**269.699,80**

J. List of items and kits for Virtual Reality lab

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1	VR headset with controller	Meta oculus quest 2Advanced all in one head set 256GB with carrying case and elite strap for enhanced	12	619	7428
2	Tracking camera	slim 13E	8	1699	1498
3	Tracking software	Motive2	1	1498	
4	Ethernet cables	cat6	10	9	90
5	Camera tracking base	OptiTrack Active base station	1	1649	1649
6	Active tag	PCB and LED (assembled)	3	349	1047
7	Network card	Intel 1210_T1	1	129	129
8	OptiTrack Hardware Key	Motive 2 Hardware Key	1	99	99
9	PoE switch	NETGEAR PROsafe GS716T	1	225	225
10	Game Engine software (Education grant License)	Unity 3D, Unreal engine	2	0	0
11	Content Creation software(Education grant license)	Blender,3D max, Autodesk, Fusion, Solidworks, Maya, Motion Builder	2	0	0
12	Scientific Engine Software	WorldViz Vizard(Parmanent academic license)	1	5000	5000

13	Laptop oculus ready Predator Helios 300 PH315-54-714U	Full HD1920X1080 Intel core i& 11th Gen i7 11800H Octa core (8core) 2.3 GHZ 16GB Total RAM 1 TB 1HDD, 512 GB SSD , Intel HM570 Chip, NVDIA GeForce RTX 3060 with 6 GB IEEE802.11 a/b/g/ac/ax Wireless LAN Standard Windows 11	2	1450	290 0
14	Workstation Computer (Oculus Ready) CyberPower	Intel Core i7-12700KF-16GB memory- NVDIA GeForce	2	1649	3298
15	Screen	Spectre E275W- 19203R 27 inch 1080 LED Monitor 99%RGB 2X HDMI VGA Built in Speaker	2	139	278
16	Screen	Sonny 65 Inch 4K Ultra HD TV X80K series	2	798	1596
Grand Total/USD					**38,829**

K. List of items and kits for General Purpose Innovation and fabrication lab

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1	Medium Duty Lathe Machine	Swing over bed : 560mm（22”） Swing over cross slide: 355mm（14”） Swing in gap diameter: 785mm（30-7/8”） Distance between centers : 1500mm（60”） Valid length of gap: 170mm（6-11/16”） Width of bed : 350mm（13-13/16”） Spindle nose: D1-8 Spindle bore: 105mm（4-1/8”） Taper of spindle bore: Φ113(1:20) Range of spindle speed: 12changes,25~2000r/min Compound rest travel : 130mm（5-1/8”） Cross slide travel : 316mm（12-7/16”）		1	25000

		Max.Section of tool: 25×25mm（1”×1”） Lead screw thread : 6mm or 4T.P.I Longitudinal feeds range: 32 Kinds,0.059~1.646mm/rev（0.0022”~0.0612”/rev） Cross feeds range: 42 Kinds,0.020~0.573mm/rev （0.00048”~0.01354”rev） Threads metric pitches: 47kinds,0.1~14mm Threads imperial pitches: 60 kinds,2~112T.P.I Threads diametral pitches: 50 kinds,4~112DP Threads module pitches: 34 kinds,0.1~7MP Quill diameter: 75mm（2-15/16”） Quill travel : 180mm（7-1/16”） Quill taper : No.5 Morse Main motro power: 7.5KW（10HP）3PH Coolant pump power: 0.1kw（1/8HP）3PH Overall dimension (L×W×H）: 434×115×146cm Packing size （L×W×H）: 440×119×174cm Net weight : 2930kg Gross weight : 3410kg			
2	Heavy Duty Lathe machines	Swing over bed : 800mm（31-1/2”） Swing over cross slide: 570mm（31-1/2”） Swing in gap diameter: 1035mm（40-3/4”） Distance between centers : 3000mm（120”） Valid length of gap : 250mm（10”） Width of bed : 400mm（15-13/16”） Spindle nose : D1-8 Spindle bore: 105mm（4-1/8”） Taper of spindle bore: Φ113（1：20）		1	37,000

		Range of spindle speed: 25~1600r/min Compound rest travel: 230mm（9-1/8”） Cross slide travel: 420mm（16-17/32”） Max.Section of tool: 25×25mm（1”×1） Lead screw thread: 12mm or 2T.P.I Longitudinal feeds range: 0.044~1.48mm/rev（ 0.00165”~0.0550”/rev） Cross feeds range: 0.022~0.74mm/rev（0.00083”~0.02774”/rev） Threads metric pitches: 54 kinds,0.45~120mm Threads imperial pitches: 54 kinds,7/16~80T.P.I Threads diametral pitches: 42 kinds,7/8~160DP Threads module pitches: 46 kinds,0.25~60MP Quill diameter: 90mm（3-1/2”） Quill travel: 235mm（9-1/4”） Quill taper: No.5 Morse Main motor power: 7.5kw（10HP）3PH Coolant pump power: 0.1kw（1/8HP）3PH Overall dimension（L×W×H）471×123×167cm Packing size (L×W×H) : 474×114×191cm Net weight: 3820kg Gross weight : 4495kg			
3	Milling machines	TABLE Working table surface(WxL) mm : 400x2000 Max.bearing weight kg : 800 T-slots(Number) : 3 T-slot(width) mm : 18 T-slot(Distance) mm : 90 TRAVEL Longitudinal Travel(X) mm : 900/880 Cross Travel(Y) mm : 315/300		1	40,000

		Vertical Travel(Z) mm : 380/360 SPINDLE Spindle taper : ISO7:24 No.50 Speed range r/min 30-1500 Speed Step 5tep 18 Axial motion distance mm Max.swivel andle dep ±45 Distance from vertical guide way to table surface Min/Max mm : 255/570 Distance from centre line of spindle to vertical guideway surface of column mm : 30/410 FEED Cutting Feed Rate mm/min X:23.5-1180 Y:15-786 Z:8-394 Rapid Feed Rate(X、Y、Z mm/min X、Y:2300 Z:770 No of feeds : 5tep 18 MOTOR Power of Spindle Motor kw 11 Power of Feed Motor kw 3 OTHER Overall dimensions(LxWxH) mm : 2556x2159x1830 Net weight kg 3850			
4	Servo Milling Machine	-Table dimensions mm : 2.000x500 -Travel X-axis mm : 1.400 -Travel Y-axis mm : 700 -Travel Z-axis mm : 500 -Speed range (2) : 30-390 / 390-2050 1/min -Spindle mount : SK 50 / DIN 2080 -Rapid feed X-axis : 2.200 mm/min -Rapid feed Y-axis : 2.200 mm/min -Rapid feed Z-axis : 1.100 mm/min -Motor rating main drive : 11 kW		1	62,000

		-Weight : 5.000 kg			
5	Servo-Conventional Lathe Machine	Working area -Center width : 1.470 mm -Turning diameter over bed : 660 mm -Turning-Ø over support : 450 mm -Bed width : 400 mm Travels -Travel X-axis : 350 mm -Travel Z-axis : 1.420 mm -Travel Z1-axis : 100 mm Headstock -Spindle speed : 30 - 1.800 1/min -Spindle bore : 86 mm -Spindle mount : A2-8 -Lathe chuck diameter : 315 mm Rapid feed -X-axis rapid feed : 4 m/min -Z-axis rapid feed : 4 m/min Feed -Feed X-axis : 0,01 - 2 mm/R -Feed Z-axis : 0,01 - 2 mm/R Tapping -Tapping, metric : 0,35 - 14 mm -Tapping, whithworth : TPI 48-4 Tailstock -Tailstock quill diameter : 75 mm -Tailstock taper MT : 5 -Tailstock quill stroke : 150 mm Drive capacity -Motor rating main drive : 11 kW -Motor rating X-axis : 1,3 kW -Motor rating Z-axis : 2,9 kW		1	40,000

		Measures and weights -Overall dimensions (length x width x height) : 3,5x1,25x1,65 m -Weight : 3.450 kg			
6	PLATTE ROLLER MACHINE	Max Thickness: 12mm Maximum Width: 2000 mm Bending Speed: 5m/min Workpiece Min Dia: 600mm Top Roller Dia: 240mm Bottom roller Dia: 180mm Distance Bottom rollers: 280mm Main Motor : 7.5kW Net Weight: 4800Kg		1	24,000
7	Radial Drilling Machine	Working area -Drilling capacity mm 60 -Tapping capacity (steel / casting) M 45 / M 50 -Drilling depth (max.) mm 315 -Spindle nose-to-table surface distance mm 350 - 1.250 -Drill head travel (horizontal) mm 1.250 Headstock -Speed range 1/min (2) 38 - 2.000 -Spindle mount MT 5 Feed -Feeds mm/min 0 - 300 Drive capacity -Motor rating main drive kW 4 -Stroke motor kW 1,5 Measures and weights -Overall dimensions (length x width x height) m 2,49x1,05x2, 78 -Weight kg 3.800		1	40,000

8	Gear Hobbing Machine	Max. Hobbing Module (Steel) 8mm Max. Hobbing Module (Cast Iron) 10mm Gear Diameter 50-800mm Gear Width 250mm		1	80,000
9	Materials for Laser Cutter	5H01 Blue 3mm cast acrylic (700mm x 400mm) 6H01 Green 3mm cast acrylic (700mm x 400mm) 3H25 Red 5mm cast acrylic (700mm x 400mm) 3H25 Red 3mm cast acrylic (700mm x 400mm) 1H01 Yellow 5mm cast acrylic (700mm x 400mm) 1H01 Yellow 3mm cast acrylic (700mm x 400mm) WH01 White 6mm cast acrylic (700mm x 400mm) WH01 White 3mm cast acrylic (700mm x 400mm) 9H01 Black 6mm cast acrylic (700mm x 400mm) 9H01 Black 3mm cast acrylic (700mm x 400mm) 0F00 Transparent 10mm cast acrylic (700mm x 400mm) 0F00 Transparent 6mm cast acrylic (700mm x 400mm) 0F00 Transparent 3mm cast acrylic (700mm x 400mm) 0F00 Transparent 2mm cast acrylic (700mm x 400mm)		1 1 1 1 1 	7.03 7.03 24.34 7.03 24.34 7.03 29.21 7.03 29.21 7.03 48.68 14.61 4.87 2.43
10	Laser Cutter	Speedy 300			38278.42
11	Computers and Accessories	Dell Optiplex 3050 Dell 24 Monitor SE2416H Dell Laptop Latitude 3380 Dell Projector M318WL			744.85 143.68 822.69 832.18
12	CNC ROUTER	PRSalpha 96-48 CNC			39398.17
13	3D Scanner	Kinect One Sensor Kinect One Sensor Adapter			160.66 265.56
14	3D Printer	Ultimaker 2+ Original Prusa i3 MK3S+ kit Original Prusa SL1S SPEED 3D Printer + CW1S BUNDLE		1 1	2737.30 894.23 2564.00

				1	
15	Small CNC Mill for Circuit Boards	Monofab SRM-20		1	4908.64
16	Vinyl Cutter	GS-24 CAMM-1 Roland 45 Blade Replacement		1 1	1701.53 12.15
17	Heat Press	Nautilus 4050 manual Clam transfer press 40cm x 50cm			485.63
18	Air Compressor	Air Compressor Aerotec Air Compressor Hose		1 1	511.19 47.47
19	3D Printer Filament	PLA Grey,PLA Black,PLA Blue,PLA Green,PLA Purple,PLA Red,ABS White,ABS Blue,ABS Light Blue,ABS Black		10	303.67
	CNC Router Tools	6mm Two Flute Upcut Endmill (6mm Shaft) - Wood 3mm Two Flute Upcut Endmill (3mm Shaft) - Wood 60° Two Flute V-Bit for V-Grooving (6mm Shaft) - Wood 90° Two Flute V-Bit for V-Grooving (6mm Shaft) - Wood 3mm Two Flute Upcut Ballnose Endmill (3mm Shaft) - Wood			19.47 9.25 42.78 33.53 18.62
	Woodworking + Metalworking Hand Tools				835.74
	DIY Electronics Tools				1432.62
	Electronics Components				1239.81
	Electronics Components (MOUSER)				4953.90
	Software	Vectric VCarve Pro - Makerspace Edition Corel Draw 2018 - Home and Student Microsoft Office			608.56 109.48 243.42

		Adobe Creative Cloud Solidworks 2023 AutoDesk Inventor AutoDesk Fusion FastScam			365.14 7302.72 2300.00
	Measuring Tools				225.65
	Health and Safety				258.19
	Consumables				270.20
	Replacement Blades				171.69
	Cables - Data & Power				634.95
Grand Total/USD					**479,168**

L. List of items and kits for Arts and design lab

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1	**Autodesk software**				
2					
3					
4					
.					
.					
N					
Grand Total/USD					

M. List of items and kits for Entrepreneurial activities lab

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD

1					
2					
3					
4					
.					
.					
N					
Grand Total/USD					

N. List of Office furniture and digital gadgets

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1					
2					
3					
4					
.					
.					
N					
Grand Total/USD					

O. List of equipment and hardware for Smart classroom

No.	Item	Specifications	Required number	Estimated unit price/USD	Estimated Total price/USD
1	Digital Devices/desktop computers	**Processor (CPU):** Intel Core i7(sixth generation and above) or equivalent **Operating System:** Microsoft Windows 10 Professional x64 **Memory:** 16 GB RAM	21		

		Storage: 1 TB internal Solid State Drive (SSD) or 1 TB internal HDD **Monitor/Display:** 24" LCD monitor **Network Adaptor:** 802.11ac 2.4/5 GHz wireless adapter **Other:** Webcam, lock, external drive for backups			
2	Interactive white board/Smart Board	**4K HDR DISPLAY** Original display with 4K Ultra HD resolution and 20-point IR touch capability and Anti-glare glass with 8 MOHS strength surface protection **DOLBY SOUND** 2 x 15W Built-in Left/Right Speakers with surround sound and automatic volume control **HD CAMERA SUPPORT** Web Camera (1080p Full HD & Ultra-Wide FOV, Built-in Microphone, USB 2.0, WDR) and PTZ Camera (1080p full HD, USB Interface, 72.5° Wide-angle Lens & 12x Optical Zoom, Remote Control) **CLASSROOM TOOLS** Writing software, write on any content, save, transfer via QR code or email. Support for annotation software **REMOTE SHARING** Easy remote desktop control & sharing. Multi-device screen share & streaming **OPS PC SUPPORT**	1		

		CPU Intel Core i5 / i7, RAM 8G, SSD 256G, USB 6 (4*3.0; 2*2.0), VGA x1, RS232 x1, DP x1, HDMI x1, RJ-45 x1, Audio Output x1, MIC x1, WIFI x1, OS (Windows/Linux)			
3	LCD Projector	HD (1920 x 1080) resolution, 3000 lumen, 10,000:1 contrast, 5.73 lbs	2		
4	Interactive LED/LCD Panels	Product name: Smart Interactive Panel For Education Calibration: Automatic(5s) / Manual Object detection: Finger(stylus) or any nontransparent objects Frame rate: 120fps Latency: < 30 ms Minimum active size: 40inch Maximum active size: 85inch(2 laser lights)/100inch(3 laser lights) Tracking technology: Laser Image Calibration Technology(LICT) Positional accuracy: 1 Pixel (Resolution: 1024 x 768) Consumption: 300mw(85inch)/450mw(100inch) Size: 20cm*4cm	1		

		Power requirements: 5V,1A Weight : 0.65kg OS Requirements: Windows XP, Vista, Windows 7,Windows8 Software: Calibration software and Application software Certification: CE, FCC, Rohs Warranty: 1 year Warranty on the device Components: 1x LICT interactive module , 1x hardkey, 1x stylus,1 x 4m USB cable, 1 x 7m USB cable, 1 x power adaptor , 2x CDs			
5	Digital podium	**Material:** Made of high quality rubber Wood with two cooling fan, louvers for heat dessipation , caster wheels **Podium Size**: Front Height- 48 inch, Height (Presenter side)- 42 inch, Width- 24 inch, Depth- 21 inch. **I/O Port**: Top : 2 USB, 2 XLR, switching for 4 devices any to any. Side : 2 USB, VGA in/out, Audio in/out, power port, power on/ off switch, inside 6 power plugs, LAN, HDMI, Splitting control. **Touch Panel**: 19”/22" Touch Panel with 75 degree adjustable tilt. **Drawer/Tray/Door**: Drawer for Visualiser, Key Board/Mouse tray and sliding top tray for Laptop.	1		

		Inbuilt PC: CPU Core i7 III Gen and above, 2/4/8 GB RAM, 500GB/1TB SATA HDD, OS, key Board and Mouse etc. **Audio System**: Amplifier(30-350 Watt), Upto 2 Gooseneck Mics, Speakers (6-60 Watt each), Wireless Mic(20Hz- 20KHz). **LED Lamp:** Integrated LED light for reading. **Cable Management:** Good quality cable management with full internal/External integration of hardware, plug and play setup.			
6	Speakers and wireless microphones	• 1800 WATT POWER: This portable high powered 2 way full range audio projection loudspeaker PA system has a maximum power output of 1800 watt peak power / 900 watt RMS • 12” SUBWOOFER 1” TWEETER: This active plus passive pair PA speaker kit is equipped with 12” subwoofers, high performance 1” tweeters and compression driver w/ titanium diaphragm for surround stereo sound reproduction and impressive bass response • COMPATIBLE WITH BLUETOOTH: This PA loud speaker is compatible with bluetooth for wireless audio streaming and works with devices like iPhone, android mobile phone, iPad, tablet, PC. • 5 INPUTS: Equipped with a USB flash drive and SD card reader, 3.5mm AUX input,1/4"	1 set		

		SpeakOn Input, and XLR microphone input for karaoke. Has a 35mm stand mount and comes with 2 stands, remote, microphone, power cable • EQ CONFIGURATION: This high powered heavy duty PA system also features a digital LCD display and rear panel rotary dial / button control center to adjust the master volume, mic volume, treble, bass			
7	Lecture Recording Camera	Camcorder type: Action Camera Brand: Canon Model Name: Professional Camcorder Special Feature: Night Vision, Anti-Shake, Time Lapse Video Capture Resolution: 1920x1080 Connectivity Technology: Xlr Has Image Stabilization: Yes Image Capture Speed: 60 fps Optical Zoom: 20 x Video Capture Format: AVCHD format and web-ready MP4 format	1		

		• Genuine Canon 20x High Definition Optical Zoom Lens • New, Advanced HD CMOS Pro Image Sensor with Improved Low-light Performance • Full HD 1920x1080 Recording Capabilities • 3.0-inch LCD Capacitive Touchscreen with Tilt able Electronic Viewfinder • Video Recording System: Compression: MPEG-4 AVC/H.26.Television System: NTSC			
8	Distance Learning Systems	Locally developed Distance learning management software	1		
9	Class room management software	Locally developed class room management software	1		
10	Headphone	• Connection: Wired/Bluetooth • Plug type: 3.5mm+USB plug • MIC: 4015 omnidirectional -42dB±2dB • Cable length≥2.1M Speaker diameter: 40mm • Sensitivity: 118dB±3dB • Frequency response: 20Hz～20KHz • Speaker impedance: 32Ω±15% • Wearing Method: Headphones	21		
11	External hard disk	• Hard Disk Capacity : 1 TB • HDD Type: 3.5" HDD • Rotational speed: 7200 rpm	21		

		• Transfer rate: 480 Mb/s • Access time (typical): 8.5 ms • Cache memory: 32 M			
12	Photo Copier, scanner and printer in one	• Function: Print, Copy Scan • Scanning Resolution: 600dpi * 600dpi • Size: 622mm x 638mm x 580.4mm • Max. Print Area: A3+ • Print Speed:50/60 • Zoom Range: 25% - 400% • Warm-up Time: 30 • Print resolution: 1200*1200 (Max)	1		
13	Smart TV	• Screen Size: 75 inches • Interface Type: LAN • Resolution: SVGA(800*600), VGA(640*480) • Receiving System: PAL, NTSC • Refresh Rate: 24P(24Hz) • ANT in (IEC terrestrial/cable): 2 Piece • Standard VESA: 400X400 • Private Mold • Type: LCD • Wide Screen Support • Display Format: 1080p (Full-HD) • Backlight Type: LED •	1		
14	Computer table	• Specific Use: Computer Desk	21		

		• General Use: Commercial Furniture • Application: Home Office • Design Style: Modern • Material: Metal/wooden • Style: PC Desk			
15	Computer chair	• SEAT/BACK ASSEMBLY: The seat & back is made up of 1.2 cm thick hot pressed plywood are upholstered with contoured lumbar support for extra comfort. BACK SIZE :39.0 cm (W) X 24.0 cm (H)., SEAT SIZE: 44.0 cm (W) X 41.0 cm (D) • POLYURETHANE FOAM: The polyurethane foam is moulded with density=45 +/-2 kg/m3 and hardness = 20 +/-2 on Hampden machine at 25% compression. • SEAT/BACK COVERS: The upholstered seat is covered on the underside with black polypropylene non-woven fabric and the upholstered back is covered with a back cover injection moulded in black Co-polyer Polypropylene. • ARMRESTS : No Armrests. • ADJUSTABLE BACK MECHANISM: The adjustable back mechanism is designed with the following feature: 360o revolving type Provision for backrest tube (3.5 cm X 168 G). Back height adjustment 9.0 cm, Ubfinite locking of back height.	21		

		• PNEUMATIC HEIGHT ADJUSTMENT: The pneumatic height adjustment has an adjustment stroke at 9.0 cm • PEDESTAL ASSEMBLY: The pedestal is fabricated from 0.2 cm. Thick CR steel, power coated and fitted with an injection moulded black Polypropylene hub cap and 5 nos. Twin wheel castors. (castors wheel dia. 5.0 cm). The pedesta is 55.0 cm pitch-center dia. (65.0 cm with castors) • THE WHEEL CASTORS: The twin wheel castors are injection moulded in Black-Nylon.			
16	File cabinet	Material Steel Cabinet Product Dimensions 14.3"D x 18"W x 24.5"H Special Feature Mobile • 2 lockable file drawers accomodate letter-size hanging files • Designed with stylish embossed drawer fronts and 4 roll casters for easy mobility • Smooth suspension with three-quarter drawer extension • 2-drawer file cabinet perfect for personal use and where space is limited	2		

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17	Instructor swivel Chair	• Feature: Adjustable (height), Extendable, Revolving • Specific Use: OFFICE CHAIR • General Use: Commercial Furniture • Application: Home Office, Bedroom, Villia, Apartment, Office Building, Mall, Workshop, Storage & Closet, Home Bar • Design Style: Modern • Material: Synthetic Leather • Style: Executive Chair, Lift Chair, Mesh Chair, Swivel Chair • Color: Optional • Design: Morden Office Fruniture • Seat: Soft Seat	1		
18	Instructor table	Desk design Pedestal Desk Product Dimensions 47"D x 26.5"W x 22.75"H Color Any color Room Type Office Shape Rectangular Style Classic Finish Type Metal • Durable, high-performance steel construction stands up to rigorous use • Mahogany laminate is scratch-resistant, stain-resistant and water-resistant	1		

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		• Center grommet allows easy cord management for convenient organization • Reinforced, double-frame inner structure keeps desk sturdy for years of use			
Grand Total/USD					150,639.00

P. List of miscellaneous equipment and items

No.	Required Items	Specification	Required number	Estimated unit price/USD	Estimated Total price/USD
1					
2					
3					
4					
f.					
.					
N					
Grand Total/USD					