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The Integration of General Education and Higher Education by Using STREAM and PBL Strategies

Muhammad Al-Zahrani[1] and Ayman A. Aly[2,3]

[1]*Educational Pioneer and Robotics Instructor, Administration of Activism, Taif Education Administration, Taif, Saudi Arabia.*

[2]*Professor of Mechatronics Engineering, College of Engineering, Taif University, Taif,PO Box 888, Saudi Arabia.*

[3]*Mechanical Engineering Department, Faculty of Engineering, Assiut University, PO Box 71516, Assiut, Egypt*

***Corresponding Author:** Muhammad Al-Zahrani, Educational Pioneer and Robotics Instructor, Administration of Activism, Taif Education Administration, Taif, Saudi Arabia.*

ABSTRACT

The integration methodology of STREAM (Science, Robotics, Technology, Art, Engineering, and Mathematics) in general education and PBL (Project-Based Learning) in higher education is a sufficient teaching strategy in which students gain knowledge and skills throughout working for an extended period of time to investigate and respond to an authentic, engaging in complex questions, problems, or challenges. When engaged in standards-focused STREAM and PBL, students at an early age are working in teams to experience and explore relevant, real-world problems, questions, issues, and challenges; then creating presentations and products to share what they have learned. The educator's role is one of coach, facilitator, guide, advisor, or mentor; it is not one of directing and managing all student work. Well-designed projects that meet PBL criteria differ from activities, or even projects, that have been traditional in the classroom. This study describes and evaluates the use of STREAM solution in general education throughout PBL in the Higher Education to teach and design progress and integrated skills of Robotics activities at schools in general education which serves the engineering education at Taif University, Saudi Arabia. In addition, the study first considers the development of STREAM and PBL as a distinguished tool to solve problems with creative methods which support the higher level thinking. Also, this process of learning strategy is personalized in a progressive it environment by students asking important questions, and making changes to products and ideas based on individual and collective response to those questions. A detailed description of the education outcome evolution is observed during the final year of engineering degree programs.

Keywords: *Integrated, STREAM, Project-based learning,Problem-based learning, Mechatronics engineering.*

INTRODUCTION

Engineering education is in a state of flux with Universities facing requirements fromindustry to develop graduates with a wider skills base while at the same time arevolution in the availability of information is changing the way that students learn. Project-based learning (PBL) is a student-centered pedagogy that involves a dynamic classroom approach in which it is believed that students acquire a deeper knowledge through the actives exploration of real-world challenges and problems [1].

Students learn about a subject by working for an extended period of time to investigate and respond to a complex question, challenge, or problem.[2] It is a style of active learning and inquiry-based learning.According to the Buck Institute for Education (BIE), project-based learning has its roots in experiential education and the philosophy of John Dewey. The method of project-based learning emerged due to developments in learning theory in the past 25 years. The BIE suggests, "Research in neuroscience and psychology has extended cognitive and behavioral models of learning — which support traditional direct instruction — to show that knowledge, thinking, doing, and the contexts for learning are inextricably tied.Thomas Markham (2011) describes project-based learning (PBL) thus: "It integrates knowing and doing".

Students learn knowledge and elements of the core curriculum, but also apply what they know to solve authentic problems and produce results that matter. As a result, students take advantage of digital tools to produce high quality, collaborative products. PBL refocuses education on the student, not the curriculum which is a shift mandated by the global world. It rewards intangible assets such as drive, passion, creativity, empathy, and resiliency. These cannot be taught out of a textbook but must be activated through experience with projects.“Projects” can represent a range of tasks that can be done anywhere by researching to solve problems or consulta group of experts. So that a project is meaningful if it fulfills two criteria. First, students must perceive the work as personally meaningful, as a task that matters and that they want to do well. Second, a meaningful project fulfills an educational purpose.A project should give students opportunities to build such 21st-century skills as collaboration, communication, critical thinking, and the use of technology, which will serve them well in the workplace and life. This exposure to authentic skills meets the second criterion for meaningful work an important purpose. A teacher in a project-based learning environment explicitly teaches and assesses these skills and provides frequent opportunities for students to assess themselves.Also, thisprocess of learning is personalized in a progressive it environment by students asking important questions, and making changes to products and ideas based on individual and collective response to those questions. In PBL, the projects only serve as an infrastructure to allow users to play, experiment, use simulations, address authentic issues, and work with relevant peers and community members in pursuit of knowledge.

On the other hand, the acronym "STREAM" stands for (Science, Robotics, Technology, Art, Engineering, and Mathematics). It isthe modern version solution of STEM which was first used in 2001.And then, it became STEAM. The insertion of the “A” represents the Arts, which some critics of STEM felt was a vital component missing from STEM. Recently, the inclusion of an “R,” changing STEAM to STREAM.“R” can represent Robotics. Successful STREAM curriculum strives to seamlessly integrate Robotics into the STEAM content areas of Science, Technology, Engineering, Arts and Mathematics and is an effort that requires school-wide planning, support, communication, and development. Fortunately, it was used forbridging the educational gapbetween Generaleducation and the higher education. This gap occursobservably instudents' scientific and technical skills whorecentlyjoin universities[7].

The main objectives of this paper are:

1. The integration goes continuouslywith the General Education passing through the Higher Education for bridging theEducational gap between them.
2. Using the most appropriate solution at the two levels to make simple interconnection. "STREAM"is used as a solution for the general Education levels. On the other hand "PBL" is applied to identify the mostappropriate tools forMechatronics Engineering field
3. Demonstrating of theprojects designing andimplementation.
4. Illustrating how evaluation can be used todetermine the effectiveness of STREAM and PBL Solutions.

The Design Experiment of STREAM Solution Module at Department of Scientific Activism, General Education

Robotics in education is one of the best technological and educational tools to integrate all of the movements previously described. Using robotics introduces students to emerging and innovative technological creations, as well as encouraging their participation in the act of making, which, in turn, nurtures them to become active creators rather than consumers of technological products in the future. On the other hand, STEAM education offers students one of the best opportunities to make sense of the world holistically, rather than in bits and pieces. STEAM education removes the traditional barriers erected between the four disciplines, by integrating them into one cohesive teaching and learning paradigm. Educators and others have referred to STEAM as being an interdisciplinary approach. STEAM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, art and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEAM literacy and with it the ability to compete in the new economy. One solution to bringing critical and creative thinking to the classroom and filling the skills gap: implementation of students' problem-based science, technology, engineering, art and mathematics (STEAM) programs. We must define STEAM programs, as well. We mean hands-on, rigorous learning that integrates multiple disciplines. By this definition, students in a STEAM classroom lead their own learning, find solutions to problems that reflect reality in all its complexity, and practice critical and creative thinking. STEAM bridges the gap between the theoretical and the practical,‖ says Quinn Woodard, a lead electrical engineer at Chevron and alumnus of Project Lead The Way "PLTW"‘s STEAM programs. Students aren‘t expected to take concepts from a book and regurgitate them back onto paper but to apply them to solve contemporary problems. The great thing about STEAM education is the fact that many of the problems don‘t have one solution. It challenges students to think outside the box.‖ In addition, the collaborative environment of STEAM classrooms helps students further expand their thinking and apply their skills in new situations. Through collaboration, students must discuss, clarify, justify, and evaluate their ideas, the way business professionals are required to do every day. What does a STEAM classroom look like in action? How could critical and creative thinking play out? In a middle school classroom, for example, students may embark on a project to design and model a new playground. They begin by exploring playgrounds as an engineer might: conduct interviews and research with community experts on safety and equipment longevity; measure existing equipment and space to determine the best size and location for new equipment; review concepts such as speed, force, and potential and kinetic energy that take fun and safety into consideration; or using design software to create a virtual image of their designs; and construct and test a scaled model, which they may start to introduce them into the elementary school students to get real creative and qualified engineers. Absolutely, that comes with a high-quality STREAM program helps students to build their skills both want and need including creative and critical thinking for all future generations,[7].

Students’ Learning

The module employs group work with weekly presentations by students to show experts their learning progress and inter-disciplinary projects.On completion the students should be able to:

1. Formulate design solutions to open-ended problems.
2. Learn to work in an inter-disciplinary group working environment.
3. Develop an understanding of the mechanical principles through which structures carry load and transfer loads through elements into the ground.
4. Consider the wider social and environmental aspects and identify risks associated with their schemes.
5. Demonstrate effective presentation skills

Each year there is one problem which is handled by mechatronics students working together (for example in the current year they designed a sun tracker system). The use of innovative solutions and materials is encouraged. Students have the freedom to choose the structural form of their solutions and unusual solutions are actively encouraged through the marking scheme. In addition at the end of each session, the external expert presents a solution which invariably incorporates details and products that are novel.

Increasing problem complexity at the beginning of the semester is relatively simple. However, in practical terms, the use of outside experts sometimes involves rearranging the pre-determined schedule.

Design of PBL Modules on TU

Design and Implementation of Level Tank Control Using Arduino (The first case study).

The main step to design alimpid learning track for students is to give them certain projects to be chosen. So a group of them selected a"Level Tank Control"**.** And the importanceof their selection was, thefluid level control is vital in the chemical and process industries,especially pharmaceutical industries. Some processes need Fluid to be pumped to a certain desired level. This work presents the development of On/Off and Proportional-Integral-Derivative (PID) controllers for controlling the desired Fluid level of a tank in theory. This system is able to continuously maintain and doing necessary processes non-stop day and night. The On/Off and PID controllers are implemented based on the mathematical model of the tank by using MATLAB Simulink to test the behavior of the system when inputs change. The performance of the system is evaluated in terms of Rise Time (T_r), Settling Time (T_s) and Steady-State Error (SSE) then compared with a conventional On-Off controller. Arduino board is used as an acquisition board for collecting sensor's data from the levelof the water in tank system as voltages generated according to standards. The design is implemented into a model built for a Mechatronics laboratory.

Process control is accomplished by observing a parameter, comparing it to some desired value, and initiating a control action to bring the parameter to as close as possible to the desired value.Real time monitoring and controlling are widely used in industry branches like food, pharmaceutical, chemical, filtration, nuclear power generation plants, spray coating, etc. The problem of water level control is very often encountered. Usually, it is required that Fluid level is critically maintained at a specific height, [5]. An automatic controller is applied to maintain the height of a fluid (water) in a tank. The feedback control structure is the most common control structure in the industrial control system. In this study, the feedback control strategy is applied with On/Off and PID controllers using an Arduino. Fluid level is detected by an ultrasonic sensor and then a pump is controlled accordingly to maintain the required level of the tank. Several circuits are put together to ensure the proper working of this design and block diagrams were provided in this work. The system is able to continuously maintain the level of a fluid in a tank nonstop day and night without human interference, [6].

Objectives of the Project

1. To design and fabricate an automatic model water level control with a high degree of accuracy using the On/ Off and PID controllers.
2. To build a real scale project model process control in the Mechatronics laboratory and replace the expensive Lab's equipment.
3. To implement the existing PID controller into a control process.

The model forms a useful tool to consider the PBL module case studies in civil engineering which is taken by the students in the final year of Engineering course in Mechatronics Engineering at TU.

A simple block diagram shows the connection between the components and the reaction of input to the output. (see Fig.1)

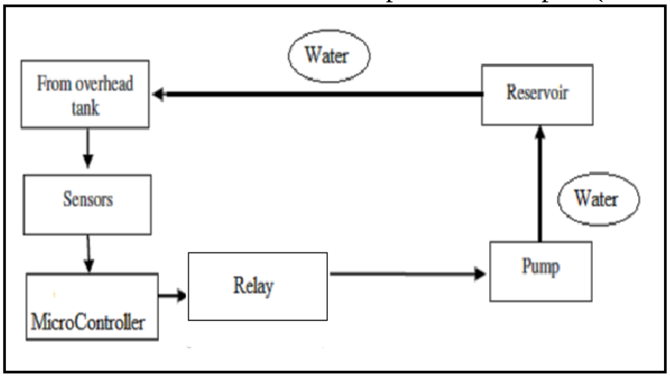

Fig1. *Simple block diagram of the system.*

Modeling of systems requires us to determine the relationship between input and output signals, here determine the relationship between the input flow and output level as shown in Fig.2.

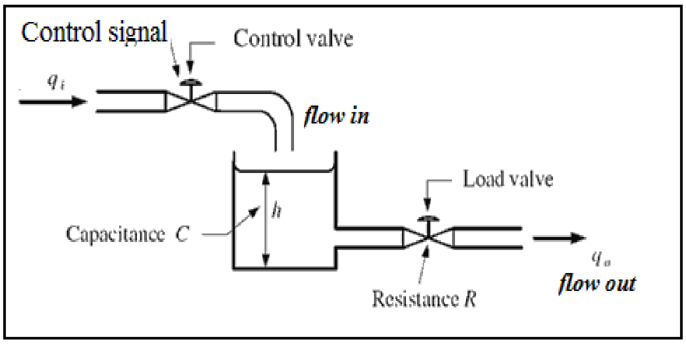

Fig2. *The position of flow in, control valve, height, load valve and flow out the relation*

The transfer function has been simulated on MATLAB Simulink to know the response of the system when the control either On/Off and PID is implemented. In Fig.3 the On/Off and PID control algorithms were implanted in the process.

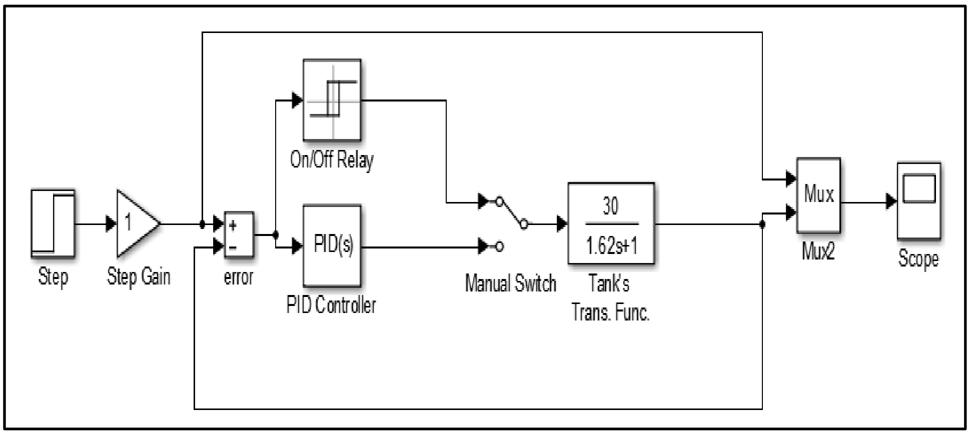

Fig3. *PID and On/Off control of water level simulation*

A pump was chosen using criteria analysis as the ultrasonic criteria analysis, a problem was encountered as pumps were not found in the local market. We needed a DC motor pump in order to control the rate of speed of the rotation of the motor hence, the flow of water. An AC centrifugal pump was chosen because it is commonly found inside a submersible fountain pump and some air conditioning units. As the impeller inside it turns, water is drawn in one side of the pump. It is then expelled out the other end. The power and size of the impeller decide the amount of water flow. More water can be pumped if we have a larger impeller. As the impeller rotates, it moves water from the inlet (which is located near the center of rotation of the impeller) along the surfaces of the impeller to the outer portions of the voluteby means of centrifugal force (thus, its name centrifugal pump). As this water collects in the outer regions of the volute, it is directed to the outlet. The water leaving the outlet causes the water pressure to drop at the inlet. To match the rate with which water is leaving the outlet, the pump sucks in new water at the inlet.

A prototype was constructed in Taif University's Mechatronics lab using a frame and flexible tubes using recycled materials as shown in Fig.9.The pump was placed inside the lower reservoir. Upper and lower reservoirs were connected using tubes. A sensor was placed on the upper tank.After the prototype was built, the final version was made of(PVC) pipes instead of flexible tubes to make it more professional and more appealing. Seen in Fig.4.

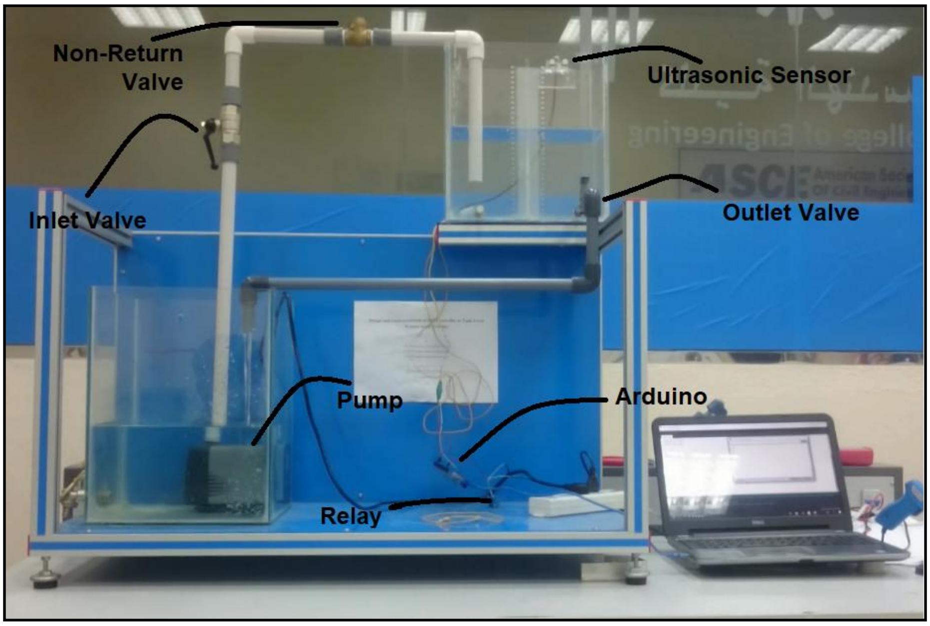

Fig4. *The complete prototype*

Flow Chart of the Design Process

The system will output an action of achieving the right level of water and to maintain it. A flow chart has been provided to clarify how the system is designed in Fig.5.

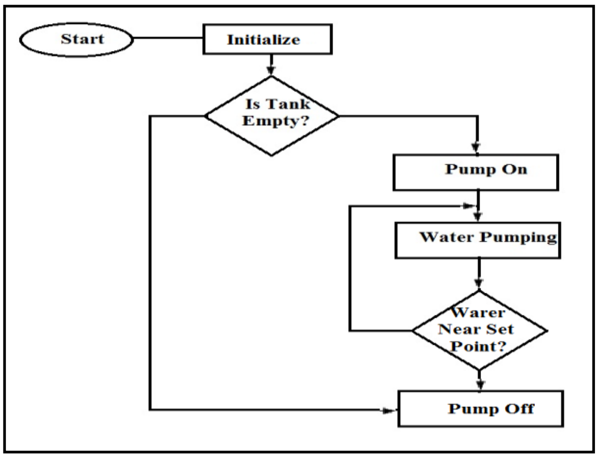

Fig5. *System designing flow chart*

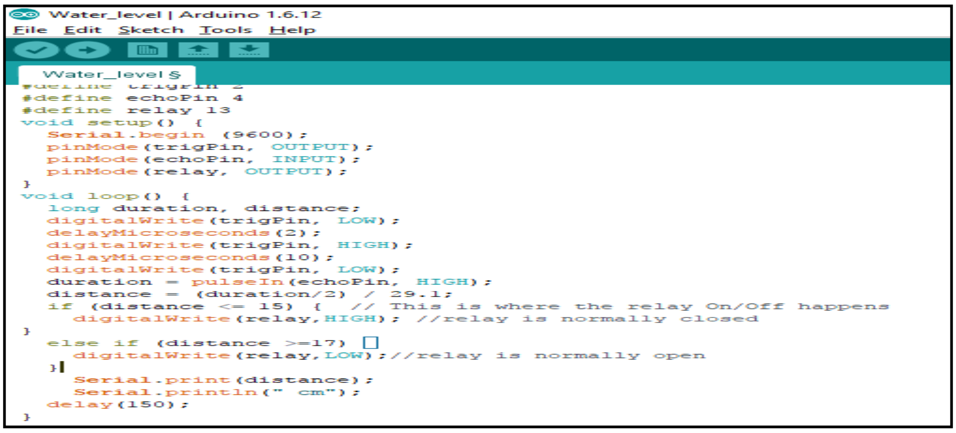

Fig6. *The system code.*

The system worked according to specification and proved quite satisfactory. It is relatively affordable, durable and efficient. Hence, give room for ease of operation and high level of reliability. The system would provide a clean and efficient way of leveling Fluid s for both domestic and industrial application thereby avoiding pollution from spillage associated with the manual control of a pump. Finally, it reduces stress associated with manual pump controller, which require that somebody go to physically switch them on or off.Results confirm that the PID control system has good adaptability in comparison with On/Off and provided satisfying results.

As already highlighted in the previous sections, the Arduino is the heart of this project work, as all the control signals pass through and are processed by the microcontroller with its code as shown in Fig.6.

This research has successfully provided an improvement on an existing water level controllers by its use of the calibrated circuit to indicate the water level and use of AC powered pump with a relay to control the electricity flow.

On a final note, the conventional controllers in the market mostly use capacitive sensors and microcontrollers. These increase the cost as well as the complexity of the system. We have developed a rather simpler but efficient model of a water level controller. We recommend this device to private individuals Government and cooperate organization where there is a need for a large consumption of water and the demand for a neat and hygienic environment free from water pollution.

Design and Implementation of a "Dual-Axis Sun TrackerControl System" Using Arduino Uno Controller (The second case study).

Renewable energy is the future for our plant especially the solar energy. Andsolar power is one of the most popular energy sources that available and can be converted intoelectricity by using solar panels. For solar panels to produce maximum output power, theincidence angle of the sunlight needs to be constantly perpendicular to the solar panel. However,most of the solar panels that used by the users nowadays are in static direction. As the sun'sposition changes, low output power will be generated. So that other group decided to makea two-axis solar trackingsystem. It was proposed to keeps the solar panel perpendicular to sunlight by using two servo motors. As shown in Fig. 7 and 8.

Mechanical engineering parts of the solar tracking system shown with free body shape. The analysis of the solar tracking system is focused on the dual-axis analysis of all parts of the system. The dual-axis analysis considers the center of gravity for the all parts, forces that affect the balance of the solar tracking system, and calculation of the torques needed for lifting the solar panel in the horizontal and vertical axis. Moreover, the dual-axis analysis considered the effect of winds on the solar panel. The first and necessary step in the dual-axisanalysis is obtaining the center of gravity for the following mechanical parts.

Fig. 7a *Dual-Axis Sun Tracking Systemfront side.*

Fig. 8a *Dual-Axis Sun Tracking Systembackside.*

As we know that the angle of inclination ranges between (-90°) after sunrise and (+90°) before sunset passing with (0°) at noon. This makes the collected solar radiation to be 0% at sun rise and sunset and 100% at noon. This variation of solar radiations collection leads the solar panel to lose more than 40% of the collected energy. Fig.9 shows the yearly sun path at the latitude of(40°).

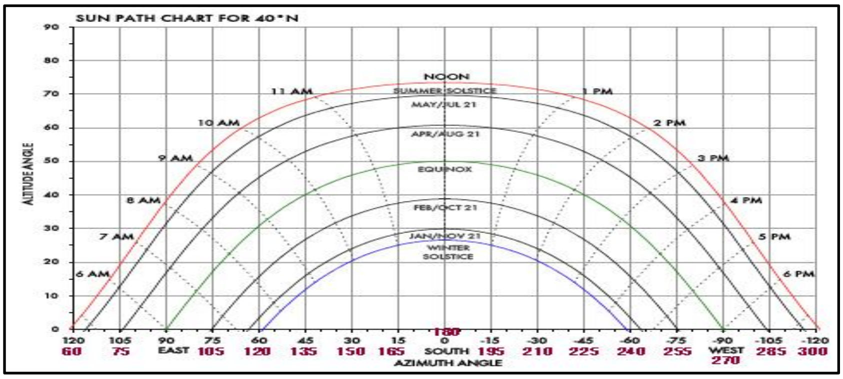

Fig9. *The yearly sun path at the latitude of (40°)*

Moreover, From the Fig.10, one can estimate the exact position of the sun every month and at any time during the day.

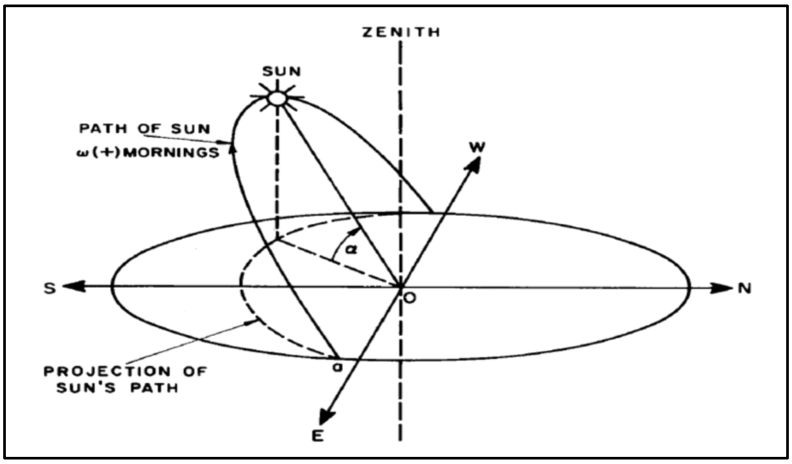

Fig10. *Earth center coordinate system for the sunray direction*

In a dual-axis tracking system, optimum power is achieved by tracking the sun in four directions. In this way, we can capture more sun rays. Movement in two axes is explained with the help of the Fig.10which is explaining the basic idea behind dual-axis tracking.

The main objective of this study is to develop the dual-axis tracking system. So that a sensor named as a light dependent resistor (LDR) is used. The resistance of these LDRsensors decreases when the intensity of light increases. Thus five volt full geared motors are used here for rotating the solarfour LDR sensors for detecting the light intensity. To track the sun movement accurately dual-axis tracking system is necessary. Thesun always faces the panel and so the greatest maximum energy can be absorbed as the panel operates at its greatest efficiency. Themain aim of this project is to improve the power gain by accurate tracking of the sun. The daily movement of the sun causes it toappear in the east to west direction over the earth whereas the annual motion causes the sun to tilt at any angle whilemoving along north-south or east-west directions. So the maximum efficiency of the solar panel is not being used by single-axis tracking system. The usage of L293D for binary data into mechanical data. Two pairs of light dependent resistors (LDR) is used as sensors totrack the sun's exact position.One pair senses the position of the sun in vertical axis i.e. from the east and west side and other pair senses in the horizontal axis i.e.from the north and south side. This sensor information is then passed to the light comparison unit. The rest LDR senses the nightmode and then the signal will be sent to the light comparison unit.A light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity. The microcontroller isthe main control unit of this whole system. The output from the light comparison unit comes to the input of the microcontrollerwhich determines the direction of the movement of the motors both in the horizontal and vertical axes. For open source application,"Arduino"microcontroller is used. The design of the light sensor is based on the use of the shadow. If the solar panel is not perpendicular to the sunlight, the shadow of the wall partition will as shown in Fig.11 cover one or two LDRs and this causes different light intensity to bereceived by the sensing device.

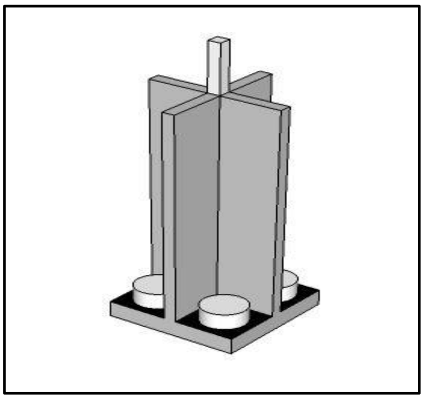

Fig11. *4 LDRs with sheets between them*

Thus, the design of a dual axis solar tracker is done and can obtain the energy from the sun very efficiently. A simple block diagram provides fast DATA processing andshows the connection between the components and the reaction of input to the output. The block diagram of the developed closed-loop solar tracking system is illustrated in Fig. 12, describing the composition and interconnection of the system.

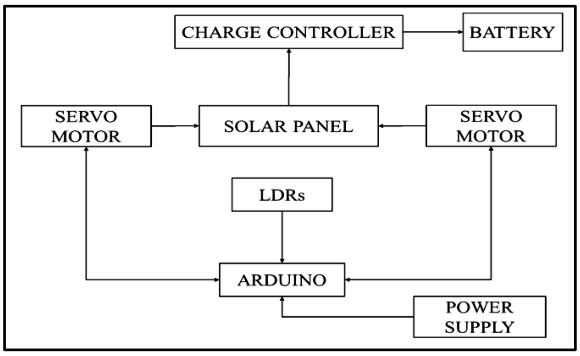

Fig12. *A Simple block diagram of the system.*

For the closed-loop tracking approach,the solar tracking problem is how to cause the solar panel location (output) to follow the sunlightlocation (input) as closely as possible. The sensor-based feedback controller consists of the LDRsensors, a differential amplifier, and a comparator. In the tracking operation, the LDR sensorsmeasure thesunlight intensity as a reference input signal. The unbalance in voltages generated by the LDR sensorsare amplified and then generate a feedback error voltage. The error voltage is proportional to thedifference between the sunlight location and the solar panel location. At this time the processorcompares the error voltage with a specified threshold (tolerance). If the comparator output goes highstate, the servomotors are activated so as to rotate the dual-axis (azimuth and elevation)tracking motor and bring the solar panel to face the Sun. Accordingly, the feedback controller performsthe vital functions: solar panel and sunlight are constantly monitored and send a differential controlsignal to drive the solar panel until the error voltage is less than a pre-specified threshold value.Another very important aspect to emphasize is that thanks to solar tracking not only the production of energy increases but also improves the way the power output is delivered. With solar tracking, you can extend the time of available maximum power and thus produce with greater capacity more hours a day.

Flow Chart of the Design Process

The algorithmstartsas iullustrated in Fig. 13 bytaking data from the four sensors (LDRs). The sensors output is analogsignals. This task is performed usinganalog to digital converter. Then digitized signals are forwarded to the Arduino's microcontroller. After collecting, it processes data and decides about the movement direction of the two servomotors.The controller algorithm is showing that Arduino drives servomotors only if sensor light (LDRs) sensing is not equal to each other.And the algorithm goes continuously ifthe four (LDRs) signals aren't equal as shown in Fig.14. This process repeated until the light falling on (LDRs) pairs is equal and solar panel is going to be in the vertical positionof the sunlight.

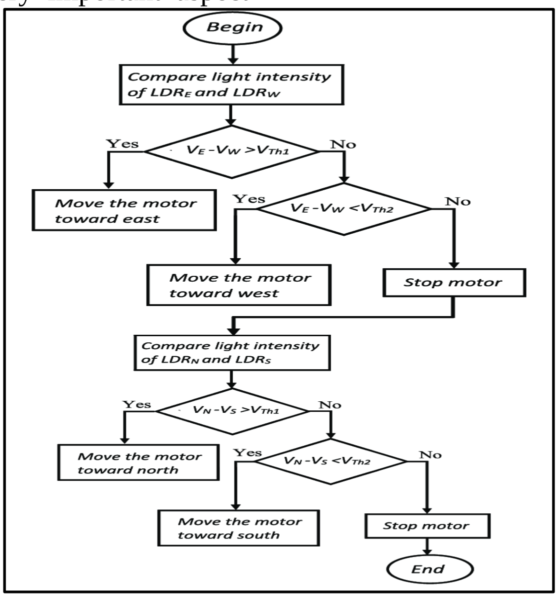

Fig13. *System designing flow chart*

Design and Implementation

In this projects include design and construction of an Arduino based solar tracker. This solar tracker system uses the Arduino board, two servomotors, four LDRs,and four resistors to rotate the solar panel towards the sunlight vertically. In this project, LDR was selected since it has no polarity, and easy to interface with circuit, cheap, reliable and is described by high spectral sensitivity, so that difference in high intensity is represented immediately by changing in its resistance value. For supporting the hardware, it stands on heavy duty basewith two feet height. For better control of tracker elevation of the panel can be increasedand it must be installed in an open air environment. The solar panel is used for the hardware implementation is12Volt and it is the monocrystalline type. In addition, there are two high torqueservomotors areused.And the main advantage of using thehigh torque servomotor is that it movesin degrees,low current actuatorand it is best suited for accurate position controland electronic components in Fig. 15.

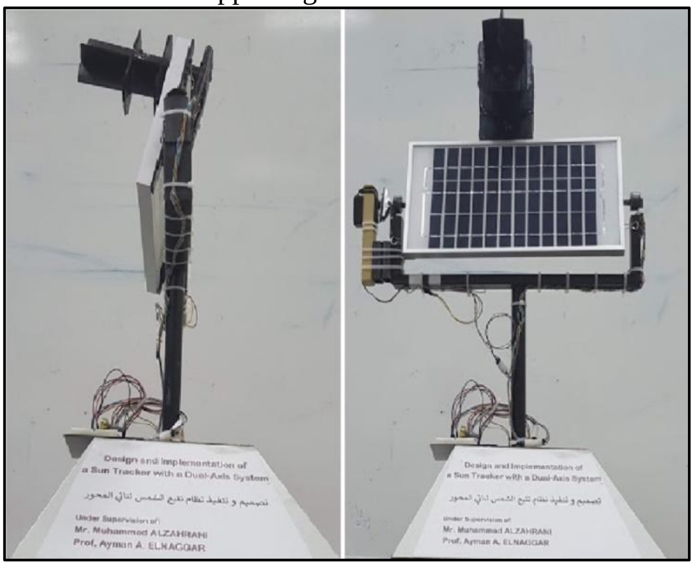

Fig14. *The Complete Prototype.*

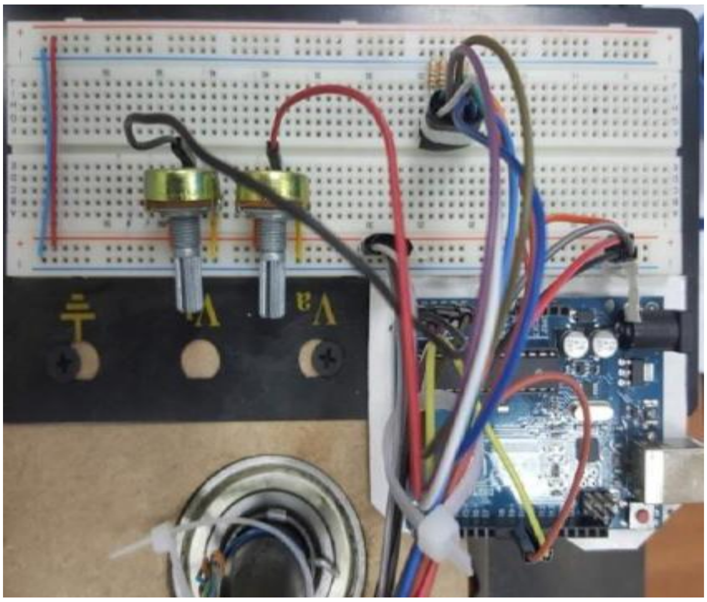

Fig15. *The Electronic Components*

The software is dumped on to Arduino Uno so that rotation of servo motor can be controlled by employing the microcontroller. The programming part consists of 5 cases which have been stated, analyzed and the(LDR) sensors give again the feedback to investigate the voltage differences from the sensor (light depending resistor LDR) based on the intensity of light received by the sensor. The output has plotted into a graph and compared with a static system. And the proposed system is eco-friendly, and widely used as shown in Fig. 16.

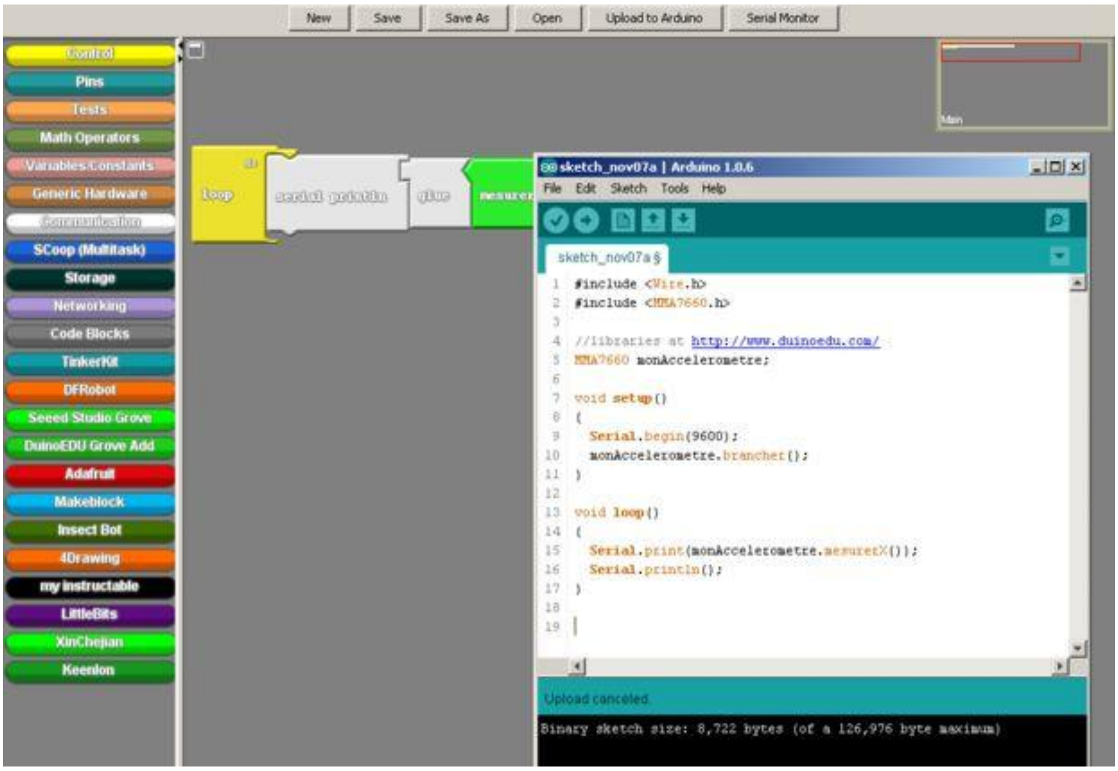

Fig16. *Program Interfaces*

The software design was done using Arduino IDE which was used for the programming. Theprogram was written using the C language. The Proteus circuit editing software was used fordrawing the PCB circuit. The design of the circuit was done using Eagle software. Fixed collectors are mounted on places that have maximum sunlight and are at a relatively good angle in relation to the sun. These include rooftops. The main aim is to expose the panel for maximum hours in a day without the need for tracking technologies. There isa considerable reduction in the cost of maintenance and installation. Most collectors are of the fixed type. When using these collectors, it is important to know the position of the sun at variousseasons and times of the year so that there is the optimum orientation of the collector when it is being installed. This gives maximum solar energy through the year.

RESULTS AND DISCUSSIONS

In order to create effective Project-Based Learning units, professional development organizers suggest using the following guidelines:

- Begin with the end in mind and plan for this end result.
- Craft the driving question; select and refine a central question.
- Plan the assessment and define outcomes and assessment criteria.
- Map the project: Decide how to structure the project.
- Manage the process: Find tools and strategies for successful projects.
- Project-based learning can involve, but is not limited to:
- Asking and refining questions.
- Debating ideas.
- Making predictions.
- Designing plans and/or experiments.
- Collecting and analyzing data.
- Drawing Conclusions.
- Communicating ideas and findings to others.
- Asking new questions.
- Creating artifacts.

The projectshave scope of work, resource, and planning activity to execute and manage the resource to get the desired results. In the present world full of ever-increasing complexity, project-based learning is preparing students to solve the real world problems.

In process-based models which use real-life problems, (wherepossible) it is important to consider a number of critical elements in the assessmentprocedure in order to enhance the quality of student learning:

- The use of student self-assessment.
- A clear description of the assessment, i.e spell out clearly thecriteria and standards required
- Clearly, demonstrate how excellence may be achieved
- Through the provision of regular, timely, detailed andconstructive feedback
- A fundamental concept of PBL is that where possible, learning
- A fundamental concept of PBL is that where possible, learning and assessment shouldoccur simultaneously. In this course,obvious examples would be projectpresentations in which the results of a problem are presented by students, and complementary skills such aspresentation, public speaking,and self-confidence are developed.
- Timing – The problems take place over two terms period.
- They are focused on the application of mechatronics engineering design principlesin practice.
- A special lecture is arranged in each week to address unusual featuresassociated with the problem,
- Students must orally present their solution each week morning and there is no facility for late submission. They, therefore, developcapabilities to meet rigid and tight deadlines.
- A consequence of the heavy workloadand tight deadlines encourages self-direction.

CONCLUSIONS

In this paper, the practical approaches provided are just a few of many successful robotics programs and projects that utilize the transdisciplinary integration of science, technology art, mathematics, coding, computational thinking,and engineering skill learning STREAM. Robotics in education effectively engages students in "active learning" by integrating hands-on learning with STREAM concepts that confirm all necessary knowledge and skills for students to become successful members of the workforce in the future. Educational robotics is an all in one technological learning tool that promotes the future success of our students. In the other hand, the recent case studies (PBL) present how to compete with students at the Higher Education and show how to deal with the hardware of the dual axis solar tracking system design and implementation has been proposed. This system increases the efficiency of the solar panel. It is completely automatic and ensures minimum maintenance at low cost. Since it is a dual axis system maximum efficiency can be obtained over a period of time. The installation and implementation of a dual axis tracking system can be placed anywhere as it does not depends on climatic conditions etc. It can be used in many applications such as automobiles, residential areas, industries, institutions etc. In order to place more number of panels, the systems have to be designed with more mechanical strength. The power consumption of the system can be reduced by improving the system design.

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