



## UTILIZING THE FULL POTENTIAL OF ROBOGAMEZ TO INCORPORATE PROJECT BASED LEARNING IN ENGINEERING PROGRAMS AT UNITEN

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### ABSTRACT

*Today, most employers look for engineering graduates who possess the right depth and breadth in knowledge; they look for graduates who are competent in their specific disciplines, but also knowledgeable in other fields. For example, employers who are looking to hire mechanical engineers, they want them to be competent in mechanical engineering as well as knowledgeable in electromechanical system, controller programming, and system integration, etc. Project Based Learning (PBL) helps students to broaden their knowledge without affecting their focus on their specific field. At the same time, PBL does not require major changes at the university, there would not be any need to create new programs or merge existing ones, nor will the students need to spend extra years studying other fields. This work reviews ROBOGAMEZ, the annual robotics competition organized by UNITEN since 2006, and its impact on the participants learning. Nearly 50% of the participants indicated that it helped them improve their technical/practical skills. Also, this work outlines a proposal to expand the role of ROBOGAMEZ to incorporate PBL in engineering programs at UNITEN, with minimal cost and/or effort.*

**Keywords:** Engineering Education, Project Based Learning, Robotics in education, ROBOGAMEZ, UNITEN.

### 1. INTRODUCTION

In most cases, engineering education is a single discipline affair, most universities offer engineering programs as specialized disciplines; mechanical, electrical, computer engineering programs, and so on. Furthermore, these programs are run by former graduates of the same field; typically mechanical engineers teach, manage, and even review mechanical engineering programs (TRAE. 2012).

While this approach has been tried and tested for decades, it is not adequate anymore. Today's challenges are multidisciplinary in nature, and so it requires a new breed of engineers, who are well versed in multidisciplinary problems, that is why most employers look for graduates who possess the right *depth* and *breadth* in knowledge (Andersson et al. 2012).

As an example, let us consider mechanical engineering graduates and their employment. Most employers want graduates who have the *depth* of knowledge in mechanical engineering and the *breadth* of knowledge of other fields, such as electromechanical control, programming, system integration, etc. (Kauffman et al. 2012).

Unfortunately, this is difficult to achieve as most mechanical engineering graduates are *single-disciplined* by education, therefore they would be competent in topics related to mechanical engineering, but struggle when it comes to other fields (Nourbakhsh et al. 2007).

### 1.1. Enhancing Single Disciplined Engineering Programs

Over the years, there were several efforts to enhance single disciplined engineering programs and broaden the breadth of knowledge gained by their students. Some universities created multidisciplinary courses such as *mechatronics engineering* programs. Others offered masters in mechatronics for mechanical engineering graduates. Some universities even offered electrical and mechatronics elective subjects in mechanical engineering programs (Nourbakhsh et al. 2007).

Multidisciplinary programs suffered from the problems facing all multidisciplinary programs; most of its members were trained in traditional, single disciplined programs, so some would remain stuck in their disciplines and became biased in their teaching, communication, collaboration, and even attitude towards other fields (Choi et al. 2006).

Master's programs worked, but not all graduates were willing to take them. Many did not want to spend more time (or effort) at the college, they just wanted to graduate and enter the field. Lastly, elective courses depended on availability, and they varied from one university to another (Labenda et al. 2012).

### 1.2. Project Based Learning (PBL)

PBL offered a practical and effective solution; PBL is applied by offering practical projects in mechanical engineering programs so it would complement the theoretical education they receive in class. These projects are multidisciplinary in nature, such as designing and/or controlling a small mobile robot. Students would use it as a platform to gain practical knowledge and broaden their knowledge (Chiou et al. 2011).

PBL can be utilized at any point in the program, and it would not disturb the infrastructure already established at the university, there would be no need to create new programs or courses. Students would not need to spend more time at the university.

## 2. LITERATURE REVIEW

In the last few years, PBL has become so popular that it has been applied at all levels of education (Nagchoudhuri, 2004). Donohue and Richards (2008) showed that PBL could be beneficial as early as elementary school; they decided to incorporate *Engineering Teaching Kits* (ETKs), at elementary school after witnessing its popularity at middle and high school levels.

In these workshops, young participants would work through activities designed for elementary grades, such as Buoyancy, Archimedes Law, and Simple Machines (Donohue et al. 2008).

RWTH Aachen University, Germany, established a new freshman introduction course. They organized the course to be a 1 week, full time, lab work for freshmen. The course consisted of three parts, mathematical methods, MATLAB programming, and practical work, with the final task was to control LEGO windstorms robots (Behrens et al. 2010).

PBL is not limited to mechanical engineering, Oliver et al. of the Autonomous University of Barcelona (UAB), utilized PBL to enhance interest in the computer engineering program offered by UAB and reinvigorate its popularity (Oliver et al. 2010).

After applying it for 2 years, they reported great results; 93% of the students participated in PBL passed the examinations with flying colors. Based on student feedback, they reported they could better understand the mixed hardware/software kernel of computers, and felt they were better equipped to work in the field (Oliver et al. 2010).

In Japan, BPL has been applied for years; many universities have been using robotic based projects as an educational tool for years. At Waseda University, they developed an inverted pendulum mobile robot, *the Waseda Wheeled Vehicle No. 2*, as an educational tool to demonstrate the principles mechanics, kinematics, and mechatronic systems (Solis et al. 2009).

Rather than just develop an introductory course, the Department of Mechatronics in Chungnam National University (CNU), Korea, developed a BPL based engineering program; their Mechatronics Engineering Degree is designed around practical robotics projects (Jung. 2013).

### **3. PROBLEM FORMULATION: THE NEED FOR PBL IN UNITEN**

Upon reviewing the list of titles for FYPs for mechanical engineering at UNITEN, one can see that most students have selected titles that are purely mechanical in nature, with little or no electrical or programming elements. When questioned, students said they did so because they struggled to handle any title that was not purely mechanical.

This highlighted how single-disciplined mechanical engineering students are. If they struggled over FYPs title selection while still in college, it would be inevitable that they would also struggle in the field. That is off course if they were able to secure employment.

#### **3.1. ROBOGAMEZ as a platform for implementing PBL in UNITEN**

UNITEN has been organizing ROBOGAMEZ since 2006. It is a robotic competition where students/designers build robots to compete/complete specific tasks; sumo wrestling, king of the mountain, and others. The event is open to all science based students from primary school all the way to university level.

ROBOGAMEZ is organized by UNITEN's *Mobile Robots Club* (or MRC), a club managed by senior engineering students enthusiastic about robots and automation. Students from MRC organized and managed every aspect of this event under the supervision, guidance, and support of the faculty of engineering. Few months before the event, MRC would organize a series of workshops on mobile robots design, control, programming, and project management.

The first objective of this work is to investigate the impact of ROBOGAMEZ on the learning experience of its participants, whether or not it impacted their engineering learning experience or not. Secondly, and based on that understanding, this work would propose an initiative to expand the role of ROBOGAMEZ and use it to incorporate project based learning in engineering programs at UNITEN.

### **4. METHODOLOGY**

Surveys were used to gage participants' learning experience in ROBOGAMEZ. Participants consisted of various levels of education; most of the respondents were students from higher institutions. The questions covered the respondents' background, efforts towards the competition, and how it affected on their learning efforts throughout the competition.

Across the two days event, questionnaires were handed out to each participant upon registration and collected at the end of the event. 50% of the respondents were students of higher learning institutions, 30% were from upper secondary school, while the remaining 20% were from lower secondary schools.

Many statistical tools were used in determining the adequacy of the sample size; the primary tool used for this work was MACORR online (MACCOR. 2013). A population of 300 students with 95% confidence level and 15% error level were expected. For the data to be valid, the required sample size was 37 respondents, the survey managed to collect a total of 43 respondents. This meant the number of responses was adequate enough to represent the whole event population and fulfill the objective of this survey.

### **5. DISCUSSION**

The survey results are shown in Table 1 (below). As it can be seen, 88.37% of the participants were male compared to only 11.63% female participants. Results in Table 1 also show that 44% of the participants were exposed to robotics prior to the competition; while more than 50% were not.

Early exposure to robotics helped the students compete in the games. This was demonstrated throughout the competition; groups that managed to survive early eliminations and reach the finals and/or win prizes were mostly made up of those who were exposed to robotics prior to the games.

Not only did this experience help these groups get ahead, it also helped them reduce the time needed to prepare for ROBOGAMEZ, most of these teams required less than 3 months. This also helped them expand the possibilities of preparation, they were able to optimize designs from

previous competitions and benchmark their designs to the current trends and technologies.

**Table-1.** Profile of participant

	No of respondent	% (95% CI)
Total	43	
Gender		
Female	5	11.63
Male	38	88.37
Preparation for the event		
< 3 months	38	88.37
< 6 months	5	11.63
Have taken Robotic subject?		
YES	19	44.19
NO	24	55.81

Abbreviation: CI, Confident Interval (definition: A confidence interval gives an estimated range of values which is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data (Statistics Glossary. 2013). See also (Stattrek. 2013), and (NisSematech. 2013).

### 5.1. Impact of ROBOGAMEZ on the learning outcomes

All the participants showed strong desire towards the competition and prioritized preparation for this event over studying for subjects taken on same period; this is shown in Table 2. The strong desire to win in the completion motivated the students to fully focus throughout the learning process. This included preliminary studies, preparations, construction, programming, and testing. Table 2 also shows that more than 60% of the participants were recruited throughout the competition preparation period, which in turn resulted in increased interest in robotics, as almost 80% of the participants showed positive feelings towards robotics technology.

Strong support and guidance from the instructors was also present. These instructors were able to prepare these young students to work outside their schools, hone their basic knowledge, and so insure that the students were developing their skills in a right fashion.

Strong knowledge and experience in the field was a requirement for each instructor. 70% participants concurred that their instructors had the right expertise to guide them through. Most participants rated their instructors as excellent. They also commented that their instructors also gave them the space needed to become independent enough develop their skills on their own.

70% of the participants agreed that participation in ROBOGAMEZ gave them the excellent opportunity to hone their technical knowledge and apply the design process properly. They were able to formulate a design plan, tested to see if it was functional, safe, reliable, competitive, usable, manufacture-able, and marketable.

Those factors are the key success of any design. In order to successfully compensate the critical factors, a strong basic knowledge in mechanical as well as electrical fields is required. It requires effort to master these skills which could not be achieved by a few months or even a year. However, through participating in competition such as ROBOGAMEZ these skills could help improve students' technical knowledge and skills towards mechanical and electrical field.

Students nowadays are well versed on the need of sustainability. Part of the sustainable design is on optimizing the operational and maintenance practices. Utilizing the need of sustainable design philosophy may help to reduce negative impact to the environment. ROBOGAMEZ participants may not have considered this aspect or probably this is indirectly fulfilled without them realizing it in the first place. The last two questions in Table 2 asked for information regarding sustainability application throughout the event preparation and it shows that more than 50% of the participants were intercepting this factor indirectly through material utilization aspect as well as cost spending. Utilizing used material as well as minimizing cost is a good start of sustainable thinking practice.

Continuous efforts and improvements throughout the year may have led to a perfect application on these aspects since we do have a good start up currently. Overall feedback of the

participant shows that the knowledge, skills and enthusiasm towards this event have developed strong effect on the student development, and especially in the area of Robotics.

**Table-2.** Assessment on the ROBOGAMEZ learning outcomes

Statement	% ( 95% CI)				
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I had a strong desire to participate in this ROBOGAMEZ competition	0.00	2.40	0.00	40.40	47.60
I worked harder on this competition than on most subject I have taken this semester	0.00	0.00	30.95	38.10	30.95
As a result of participating in this competition, I have more positive feelings towards this field of study	0.00	0.00	19.05	50.00	30.95
Teacher/instructor guided us from beginning until end of the project	7.14	0.00	16.67	21.43	54.76
Overall I rate my instructor an excellent teacher	4.76	4.76	11.91	14.29	64.29
I have applied most of the mechanical and electrical knowledge towards this project	4.76	0.00	21.43	40.48	33.33
My technical knowledge has extremely improved throughout this project preparation	0.00	2.38	21.05	31.33	45.24
Our team have utilized most of the used material to design the product	0.02	0.02	23.81	28.57	42.85
We have successfully achieve our target with minimum cost spend	4.76	11.90	21.43	28.57	33.33

## 6. RECOMMENDATIONS

In ROBOGAMEZ, and in the role of the MRC students, UNITEN already has the platform needed to incorporate Project Based Learning to enhance its engineering programs, as follows:

### 6.1. The ROBOGAMEZ Welcome Program

MRC students would organize, plan, and conduct a welcome program, it is an introductory workshop offered for new students, all with the guidance of the faculty of engineering. This workshop is to last few days, and to include theoretical, practical, and simple programming activities. The point of this workshop is to expose these new students to various engineering technologies, and to allow them to see them in action.

### 6.2. The ROBOGAMEZ Subject Projects.

Designed for 2<sup>nd</sup> and 3<sup>rd</sup> year students, Subject projects are mini-projects related to subjects offered in the engineering programs. For example, if the subject was *Statics* then the subject project would be to *perform equilibrium analysis on a mobile robot while it is stationed on bridge*. If the subject was *Dynamics*, then the subject project would be to *calculate momentum and impact of two colliding robots*. If the subject was *C++* then the subject project would be to *write a sub-routine to make the robot perform a specific function*.

In all of these projects, students would not just create hypothetical solutions; instead they would test their work and analysis on an actual robot, in the lab, or in another facility. Once again, they would be assisted by the MRC, especially because these projects would have been developed by MRC in the first place.

### 6.3. The ROBOGAMEZ FYP Project

At this stage, students would have been exposed to mobile robots (or other multidisciplinary projects) and have worked with them on several occasions prior. That will make them ready to conduct a full fledged multidisciplinary final year project. They could design, program, and build their own mobile robot (or any other automation related title), applying all the theory *and* the practical experience they have gained the years earlier.

## 7. CONCLUSION

From the survey conducted on ROBOGAMEZ participants, it is clear that the event have had a great impact on their learning experience. Most have confirmed that their technical and practical knowledge have been improved as a result of participating in this event.

It is also concluded that the role of ROBOGAMEZ can be expanded to incorporate Project Based Learning activities in the engineering programs offered by UNITEN. Introductory programs, subject projects, as well as FYPs could be planned and created to complement their learning experience. This expansion would not require any major changes in the program infrastructure, nor will it need to hire new staff, as most of the supervision would be conducted by senior students who are members of the MRC.

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