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An Effective Build Your Own Robot (BYOR) Skill Development Course for First Year Engineering Students to promote Interdisciplinary Learning Environment

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***Abstract*— In recent years, a lot of focus has been laid on interdisciplinary subjects and projects in Engineering education. Robotics is the one field of engineering, which can be introduced at the first year to promote the interdisciplinary learning environment among the undergraduate engineering students. In this paper, we describe the curriculum of Build Your Own Robot (BYOR) Course introduced for the first engineering students as a skill development program and presented the students' learning experiences on the course based on the survey conducted for first year 780 students. The survey shows the positive feedback received for the effectiveness of the implemented course and has helped in improving the curriculum for further development.**

***Keywords*—Skill Development; Robotics; Interdisciplinary; Self-competence; C Programming; Curriculum**

***JEET Category*— Practice (Multidisciplinary Engineering Education)**

I. INTRODUCTION

Educational robotics is one field that enables students of all ages to become familiar with and deepen their knowledge of robotics and programming, while at the same time learning other cognitive skills; To create highly skilled manpower in robotics, it is necessary to introduce students to the field of robotics in secondary education itself. But some new techniques and solutions are required to bridge the continuity between secondary and higher education in robotics rather than using existing robotic kits or ready-made kits [1]. As there is no fixed method of programming and designing a robot. Therefore, robotics highly encourages students to analyze and think of various possibilities by reasoning and logical methods to come up with the best suited method. This in turn, enhances their decision-making ability and further empower them to level up as quick independent decision-makers [2][5]. An extensive survey has been conducted in [3][7] on educational robots and its applications which are used in the secondary schools and higher education institutes. Though there are various methods that are already existing in the education field to teach robotics, the authors in [4] explained robotic analysis course based on project-based learning method with a combination of Sim Mechanics, SolidWorks to build robotic systems. If interdisciplinary course like robotics is not supported in the curriculum, the skills can also be provided to the students in the form of workshops or short-term training programs. This further increases the student's developing mobility, adaptation, and introduction of innovations in modern life activity [6]. Interactivity in learning along with a robot makes it more interesting and fascinating for the student which in turns helps learning quite a lot. Robotics is not future anymore. Several developed countries are already implementing robotic courses in the regular curriculum and improve the syllabus through feedbacks and surveys [9]. India too is catching up this phenomenon and adjusting itself with their counterparts from the other side of the world. To support this, we have introduced a robotic course for the first-year engineering students as a skill development course and presented students' learning experiences based on the survey conducted at the end of the course.

II. IMPLEMENTATION OF THE COURSE

BYOR is a skill development course is introduced for the engineering students in the first semester of the program. This is a 12-week course designed to provide students with an understanding of the basic robotics concepts and principles, to introduce the recent applications and prospect of this field.

A. Objectives of the course

- The course is designed to train the students of all branches of engineering on Robotics by creating Physical (Physical + Digital) platform which inculcates the concept of "Learn by Experimenting" providing an interactive, engaging and fun-filled learning paradigm.
- The course also imparts the complete insight into design and development of Robotic Systems, through hands-on sessions.

TABLE 1
CURRICULUM DESIGNED FOR THE COURSE

Phase	Area	Content	Topics
Phase 1	Basic Knowledge	Introduction to Robotics, Basics ofElectronics	Introduction to Robotics, Resistor, Diode, Transistors & battery
			Potentiometer, LEDs, Breadboard wiring principles
Phase 2	Computer Science	Basics of C and Embedded C programming	Introduction to microcontroller, Introduction to programming software, C programming
			Microcontroller interfacing with I/O devices
Phase 3	Mechanical Engineering	Sensor processing, logic circuits, real-time processing, actuators, analog/digital conversion	Principle of Light Sensitive Sensor - LDR, Light Sensitive Sensor interfacing, InfraredLEDs, Photo diode, Photo transistor, Relays
			Infrared sensor Module, IR Sensorinterfacing
Phase 4	Electrical Engineering	Interfacing Motors and Wheeled Mobile Robot	Components of a robot, DC Motor interfacing, Servo Motor interfacing
			Applications using Sensors & motors Introduction, Assembly of a wheeled mobile robot
			Temperature & Humidity sensor - DHT11, Passive infrared sensor, Flame sensor
Phase 5	Electronics and Communication Engineering	Driving the Robot	H bridge concept, IC motor driver – L293D, IC motor driver – L298N, Interfacing the motorswith drivers, Interfacing Arduino with driver & motors, Driving along a square, circle or an S shape path
		Remote Controlled Robot	Basics of Bluetooth module, Serial Communication Basics, Bluetooth Module HC-05 connections, Building Remote Controlled Robot
Phase 6	Application development (Interdisciplinary Projects)	PID Control	Proportional, Integral & Derivative Controllerand Calibration for Line follower
		Line follower	Interfacing motors & IR sensors with Arduino, Line following algorithm, Line follower robot
		Obstacle Avoidance	Obstacle detection & avoidance logic, Obstacle Avoidance robot
		Cliff detection	Cliff detection techniques
			Cliff detection and avoidance robot
		Wall following robot	Combination of IR & Ultrasound sensor
			Building wall follower robot
		Maze solving robot	Recursive maze exploration and shortest path
			Building maze solving robot

The targeted audience for the program is the first semester students from all branches of engineering who continuously engage in the training program for a period of three months. The table 1 shows the detailed syllabus designed for the course. The designed course is carried out in six phases and each phase designed to provide the basic details of different fields of engineering includes computer science, electrical engineering, electronics and communication engineering and mechanical engineering. In phase 1, the students are introduced to different types of robotics and basic electronics components and its working principle. In phase 2, students learn about basics of c programming and microcontroller. The IDE tools will also be introduced at this level. The concepts related to sensors, actuators and actuators are taught at the phase 3. All the concepts related to different types of Motors and communication modules like Bluetooth, Wi-Fi is taught at the phase 4 and 5 respectively.

B. General Assembly

In the initial phase students are given with all the components needed to build the robot. The students will follow the step-by-step procedure to assemble the robots like assembling the motors on chassis, Wheel fixing and alignment, motor driver connections, sensor configuration and calibration, microcontroller connections etc., as shown in the fig 1. At the end of assembly process students will be well known to all the components of robots and accurate assembly processes such as screw driving, nut driving, part fitting, and component insertion. The Fig.2 shows the fully assembled robot.

Fig. 1. Students making robot assembly

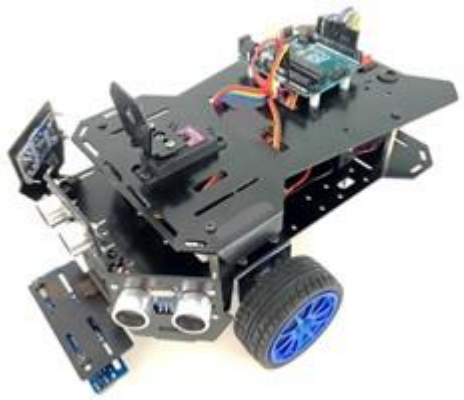

Fig. 2. Fully assembled robot

C. Basic Programming

In the mid phase, students are introduced to basics of c and embedded c programming with the understanding of programming software (IDE). Students also executes hands on simulations on I/O interfacing and programming with hardware connections. The programming related to communication modules like Bluetooth, Serial Communication also taught during this phase which intern helps in building remote controlled applications.

D. Building Applications

In the final phase of the course, the implementation of line follower robot was demonstrated to the students. The demonstration includes what is line follower robot, the working principle, sensor selection and required connection, schematic diagram of connection circuit and logical implementation of the code. The fig. 3 shows the students verifying the line follower code on the track. Finally, students were asked to implement the different applications like cliff detection, wall following robot and obstacle avoidance. With the help of mentors, students were able to implement the application successfully by understanding the logic behind the application.

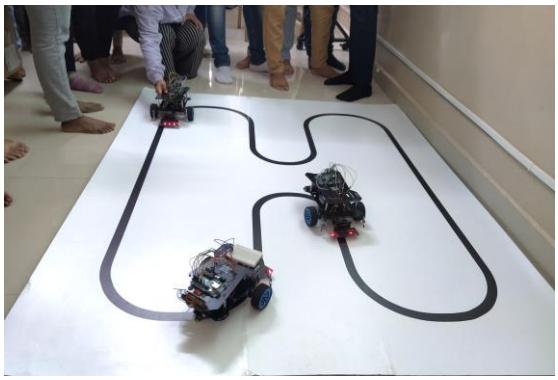

Fig. 3. Students implementing line follower robot application

E. Pre and Post Assessments

Every session had Pre- and Post – assessments to verify the students understanding about the concepts taught during the session. By establishing a baseline with a pretest, we can better track and measure student growth in each of the session. Same set of multiple-choice questions(10points) were asked in the beginning and end of the session based on the content taught during the session through google forms. Every class had 60 students. The table 2 shows the scores obtained by the students in the pre assessment and post assessment test for one session. Based on the answers given and scores obtained by the students, it is observed that most of the students were understanding the concepts clearly in each session.

TABLE 2
PRE AND POST ASSESSMENT SCORES

Particulars	Pre-assessment			Post-assessment		
Marks Scale	0-3	4-6	7-10	0-3	4-6	7-10
No. of students scored (60)	33	27	03	7	13	40

III. RESEARCH PROCESS

The research section presents the process used to collect the data which includes survey forms, questionnaire, and interviews. Students studied the course for three hours per week during 12 weeks in the first/second semester. The two surveys were conducted: an initial survey took place in the beginning of the classes, just after the first lecture, and a final survey was run in the end of the course, just before the final test. Since this course was made mandatory to all the students of first semester, 780 students were enrolled for the course but unfortunately not all the students were involved in taking up the survey throughout the course. So, we decided to choose 500 students who were consistent in the course and observe the dynamics of their learning consistently.

The survey had five sections and questionnaire related to the major background (Electronics/ Biology/ Computer Science) students in the class 12 and engineering department they belong to, basic awareness on programming languages and robotics, self-competence of the students, training strategies, impact on learning and impact on interdisciplinary approach. The fig.4 shows the details of all sections of survey process and sample questionnaire used to collect the data.

The questionnaires were given through on-line via Google forms. Questions related to each section was appeared on a separate page and questions of other section became available only after submission of a previous question's reply, and, moreover, there was no opportunity to return to previously answered questions. The questions were divided into statements, open ended questions and multiply choice questions. Each statement presented a 5-point scale with optional answers - (1) SD, Strongly Disagree; (2) D, disagree; (3) NO, Neutral; (4) A, Agree; (5) SA, Strongly Agree.

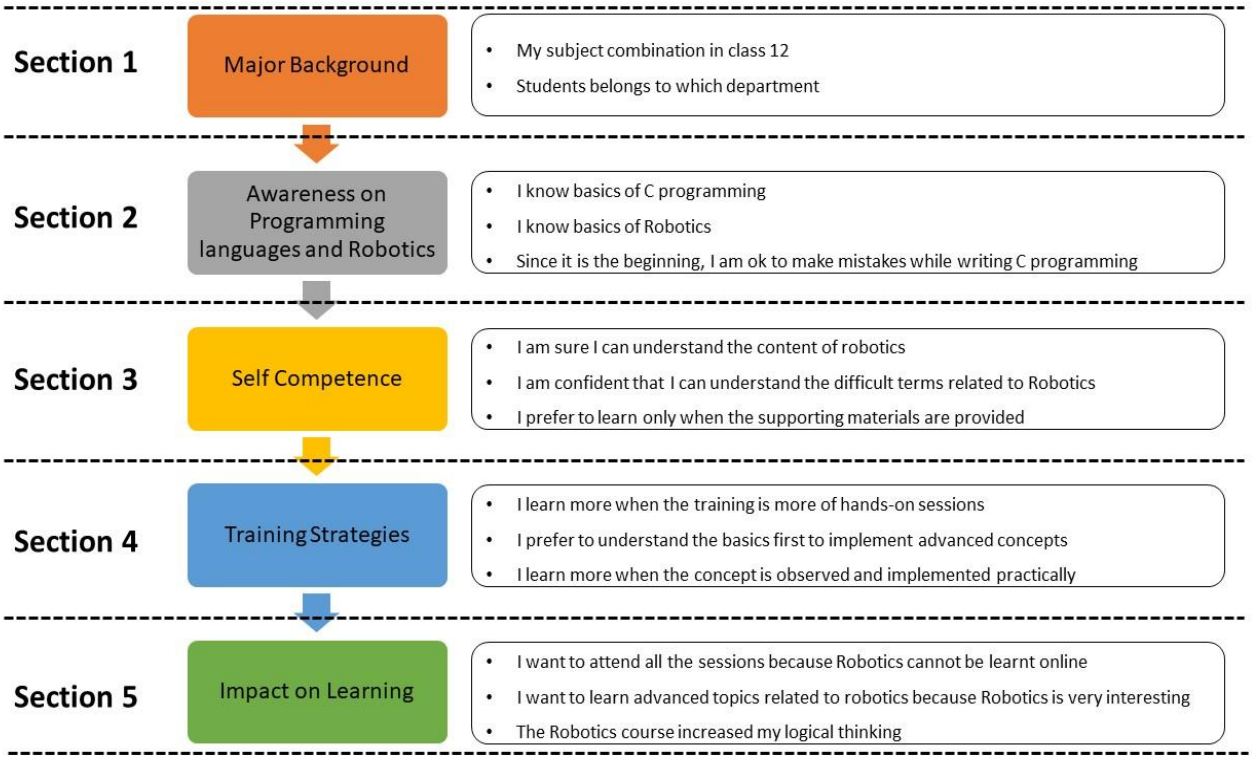

Fig. 4. Five sections of survey process and sample questionnaire

IV. Results and Analysis

In this section, we compared the students' opinions and expectations in the beginning of Build Your Own Robot course against impact on their learning after they participated in classes for 12 weeks (and just before taking a final test of the course). From the result data, we analyzed the student's awareness about the course, Self-competence, learning/training strategies, and learning impact.

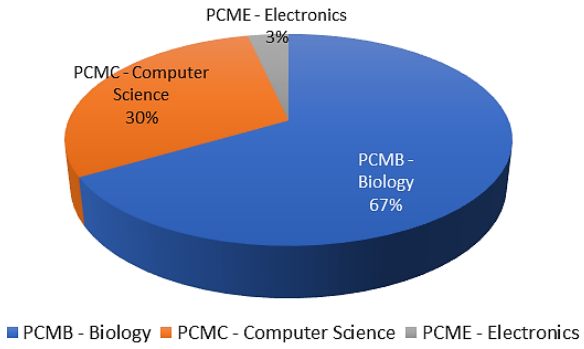

Fig. 5. Students major background in the class 12

A. *Basic Cognizance*

Based on the survey obtained in the beginning of the course, even though 70% of the students are from biology background in class 12 as shown in fig.5, over 77% (SA-26% & A – 51%) of the students confident about the basics of C programming and 67% (SA-12% & A – 55%) of the students were known to the basics of the robotics (Fig. 6 & 7). Another 10% of the students were not confident about the Programming as well as robotics as they were not having basic knowledge about the course and 20% of the students gave no opinion. At the end of the course, the student's awareness on the basics related to the course was quite positive: over 95% (increased by 28%) of the students shown confidence about the basics and 2% students had no opinion (decreased by 18%).

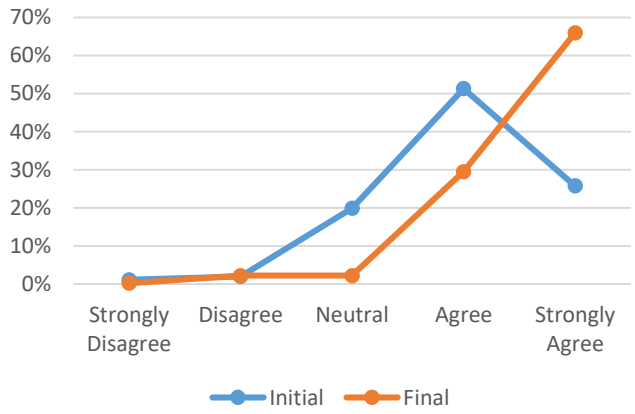

Fig. 6. I Know basics of C programming

Although 30% of the students were form computer science background in the class 12, only 3% (Fig. 8) of the students had confidence about not making any mistakes while writing C programming. Other 75% of the students were ok to make mistakes. The reason may be because, students might not be introduced to all the necessary concepts required to learn embedded C programming and robotics.

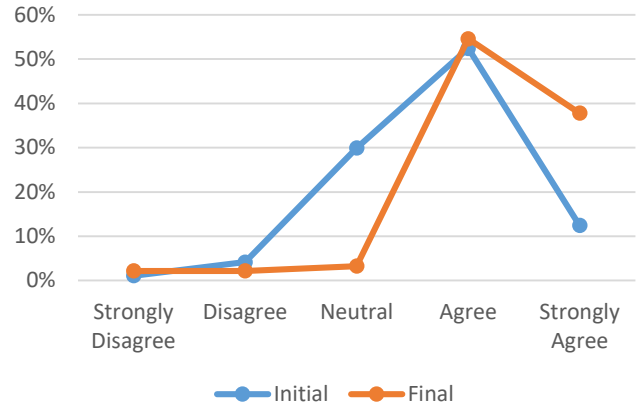

Fig. 7. I Know basics of Robotics

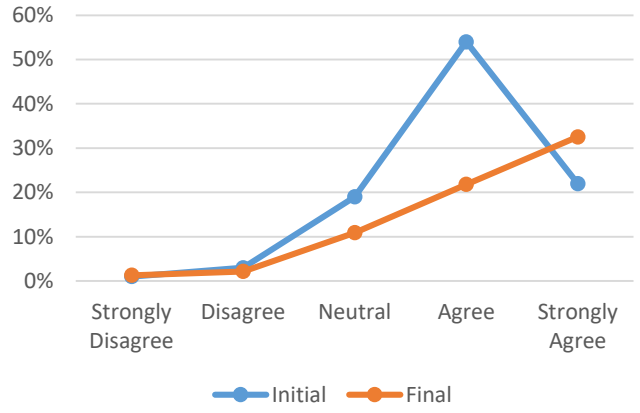

Fig. 8. I am ok to make mistakes while writing C programming

Before the commencement of the course, 82% (Fig. 9) of the students found to be motivated to learn robotics which is further increased by 15% (SA – 52% & A – 45%) after the conduction of first session. This is due to the students having the no opinion in the beginning (Neutral – 15%) changed their opinion to SA after listening to the first session.

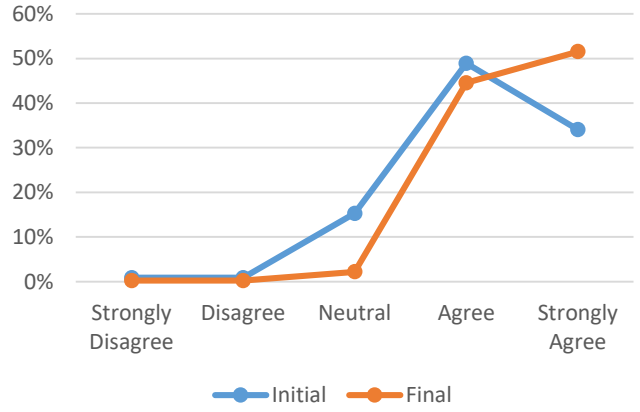

Fig. 9. After listening to the first session, I am motivated to learn Robotics

B. Self-Competence

In this section, we focused on the student's self-efficiency regarding the learning course contents and their motivation in joining the course. Overall, the students' expectations regarding the course difficulties in learning were met.

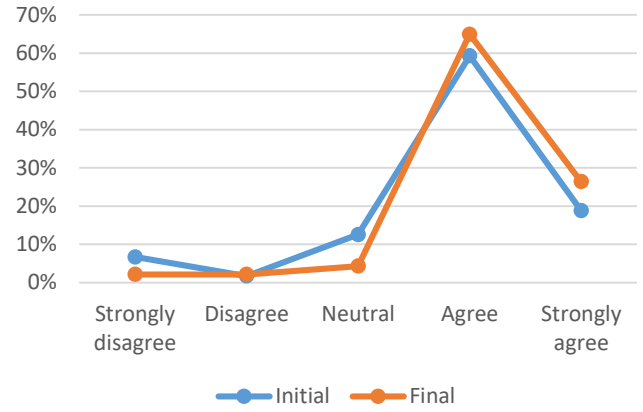

Fig. 10. Since this is basic course, I am sure I can understand the content of robotics

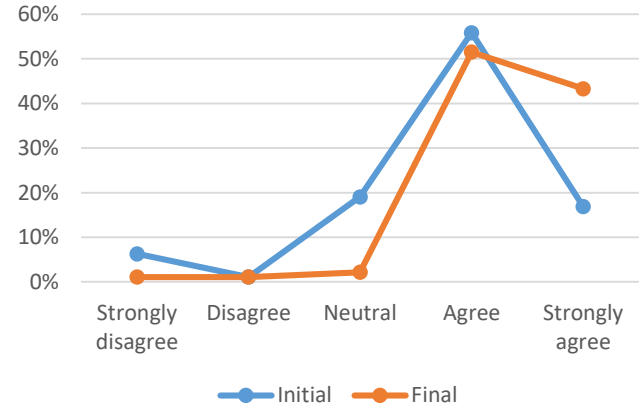

Fig. 11. I am confident that I can understand the difficult terms related to Robotics

By the end of the course, only 10% of the students (from Fig. 12) found that the robotics course is more difficult to study than they expected in the beginning. This may be due to lack of basics of robotics (Fig. 7) in the beginning of the course. On the other hand, 90% (Fig. 11) of the students could be able understand the difficult terms related to robotics from the teaches. This shows that lacking basics might not be the only reason for the students to find this course more difficult.

Even 25% (Fig. 12) of the students were not interested in the robotic course as it was not their field of interest. At the end of the course, 89% (Fig. 12) of the students were shown confidence in clearing the final assessment to get the certification.

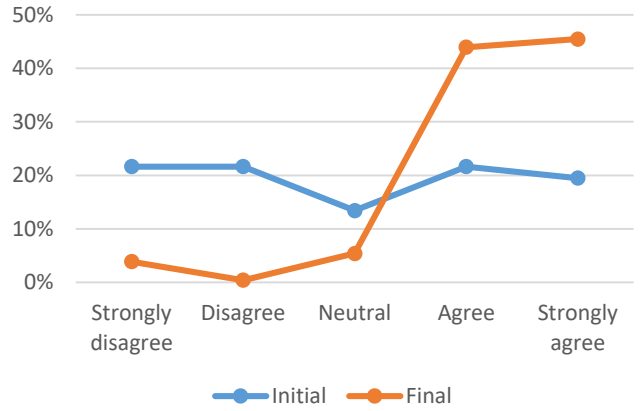

Fig. 12. I am sure I will get the final certification

C. Training and learning Strategies

Because the robotics course is skill oriented, the training strategies used by the instructors should be more of practical oriented. In this subsection, we presented and observed the impact of different training strategies used by the instructors and learning strategies used by the students to understand the course content.

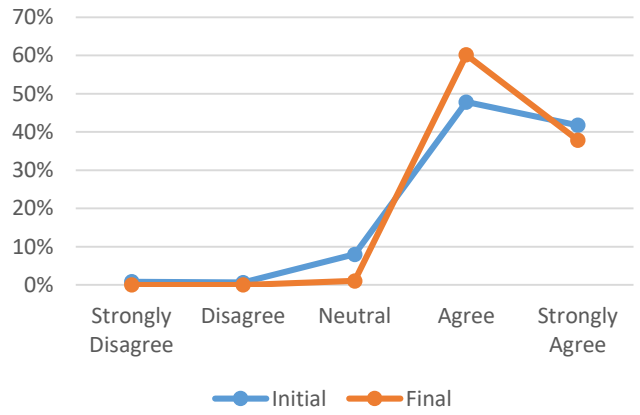

Fig. 13. I learn more when the training is more of hands-on sessions

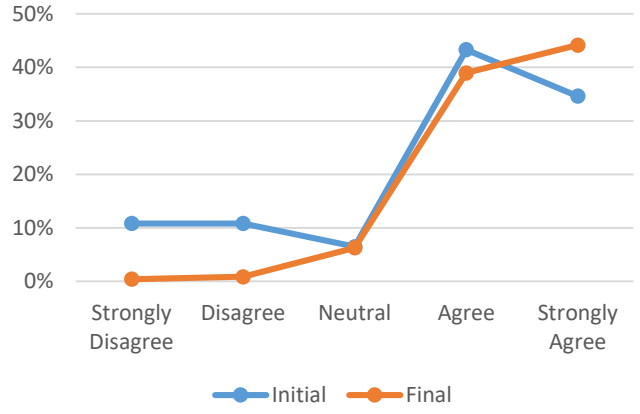

Fig. 14. I prefer to understand the basics first to implement advanced concepts

It is observed that, more than 90% (Fig. 13) of the students expects more of hands-on sessions than the traditional theory sessions. Though, initially 30% (Fig. 14) students thought that they do not requires basics to implement the advanced concepts of robotics but after the completion of the course, almost 100% of the students admitted that they need to understand the basics clearly to implement the difficult concepts. This shows the effectiveness of explaining basic concepts in all classes before explaining the advanced concepts. On the other hand, students' positive mindset towards searching for the additional content to improve the knowledge is observed. Other than more practical classes and basics classes, students also used different sources to learn robotics course when they do not understand the concept. Over 44% (Fig. 15) students dependent on the internet sources to search the content related to the concept, 37% students ask the tutor to explain, and 17% students feels comfortable to ask their friends and rest do nothing.

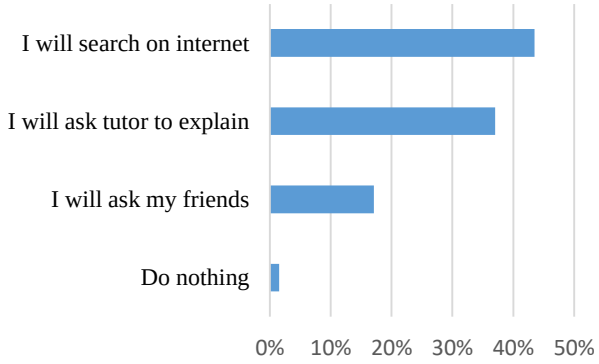

Fig. 15. When I do not understand the new concept

D. Impact on learning

This subsection shows the survey results of impact analysis on students' learning. At the end of the course, more than 80% (Table 3) of the students found that the course was useful. 80.8% students admitted that the level of logical thinking is increased after attending the course. This is because the logical skills are required to implement the algorithms for the projects like line follower robot, cliff detection etc., which were also taught to the students during the course. Because the robotics course demands lots of hands-on experiments 70% of the students agreed that the course cannot be learnt online.

Addition to the technical aspects of the course, the course also improved the team building skills of the students. Because of forming the team involving other department students while implementing the project, 80% (table 3) students admitted that they acquired the knowledge in other fields. Working in a team helps the students to consolidate learning by synthesizing ideas from many perspectives before they solve the actual problem. Because of this, the problem-solving skills improved in 86% of the students who undergone the training. With the help of survey questions related to team building skills, we understood that the attributes like logical thinking, problem solving skills, communication skills and interdisciplinary project building skills were improved among the students.

TABLE 3
STUDENTS RESPONSES FOR IMPACT ON LEARNING QUESTIONNAIRE

Questions	Percentage Distribution				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I want to attend all the sessions because Robotics cannot be learnt online	1.1	4.6	24.0	44.1	26.2
The Robotics course increased my logical thinking	0.2	1.1	17.9	53.3	27.5
I want to learn advanced topics related to robotics because Robotics is very interesting	0.2	2.2	17.7	47.8	32.1
I believe that this course will help me in understanding advanced concepts in robotics	0.7	0.7	12.0	52.8	33.8
Forming the team involving students from other departments improved my knowledge in other fields	1.1	2.2	17.7	48.9	30.1
Working in a team increased my problem-solving skills	0.2	1.7	11.6	53.9	32.5
Working in a team increased my communication skills	0.4	0.7	11.4	50.2	37.3
Working in a team helped me to build an interdisciplinary project like Line follower robot, Cliff detection, Wall following robot etc.,	0.7	0.4	11.8	56.6	30.6

V. CONCLUSION

As per the present need of the industries, students must focus on interdisciplinary knowledge and should focus on innovative multidisciplinary projects and research work. This will expose the students to the advanced technologies and will widen the scope of placements. In this paper, we presented the survey results about the robotics course. The survey was conducted in two phases: one right after the first class and second phase is at the end of the course. The initial survey results demonstrated that the basic awareness of programming and robotics might help the students for better understanding of the course. By the end of the course the students' self-efficiency and self-confidence improved, while they also realized the complexity of the robotics field. Furthermore, the students expressed motivation increase for learning robotics and used different learning strategies in studying the course. The students preferred more of practical tasks to understand the course better. The survey also demonstrated that the course improved the logical thinking, problem solving skills and communication skills among the students.

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