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An Effective Collaborative Learning: Bridging the Expertise in Engineering Education

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Abstract:*The industrial revolution in topicalera demands for drastic change in handling of educational studies. It expects cross combination of core skills providing the professional outcome deployable in the market. In line with the concept, this paper aims to present the comparative analysis of executing an engineering project using core knowledge group and interdisciplinary group. A case study is represented with evaluation parameters focusing upon the essence of collaborative learning. It is observed that, the cooperative environment helps to synthesize domain knowledge of connected disciplines which can cope with higher complexity and extended application facility. The project teams are further determined to note the scope of improvement across the defined objectives.*

Key Words:*Practice based Learning (PBL), Information Communication Tool (ICT), Internet of Things (IoT)*

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I. Introduction

In the recent decade, the learning methodologies have been geared up with the concept of interdisciplinary engineering education. These efforts make learners able to blend scholarship of knowledge and critical thinking towards creative problem solving. The attempts are made to emphasize the Practice based Learning (PBL) generating an integrated matured outcome [1].

PBL allows students to enjoy a total participation in the work assignment over traditional class room learning culture. This environment leads to brainstorm discussions to find near optimal solution to the given problem. The fundamental attribute of collaborative learning is to expand core knowledge radially across the boundaries generating a vast solution space for the problem. It inculcates the ability to employ the industry application plugins in addition to the core solution for deployable product development[2].

In a broader sense, this notion caters educational approaches encompassing joint scholarly engagement between students under the mentorship of the instructors. They are individually accountable for their work promising the structured activity. Collaboration of smaller groups helps to co-operate the students to share their strengths and also improve upon the weaker skills. Thus, it deliberates the entire efforts into the effective learning process[3].

II. Components of Collaborative Learning

Collaborative learning aims at the balanced combination of Core Intelligence, Professional Conduct and Usage of Modern Tools/Techniques as shown in figure1.The expectations under individual dimension can be described as:

A. Demonstrating Core Skills[4]:

- **Applying Core Knowledge:** Core domain of thoughts which permit a ready grasp of new, related information and therefore support early, rapid development of certain aspects of cognition.
- **Supporting Mathematical Reasoning:** Allows suitable convincing process of arriving at a conclusion based on a set of observations over the hypothesis.
- **Inspiring Critical Thinking:** Includes creating and handling meaningful learning experiences that stimulate students to think through actual and existent problems.

B. Extending Professional Conduct[4-6]:

- **Enhancing Problem-Solving approaches:** Collaborative learning involves clear stipulation of an educational task with instructions that require students to discuss the work so as to come up with solutions to the problem.

- **Developing Communication Skills:** It makes students ableto communicate both on intellectual and emotional levels by explaining their thoughts, expressing feelings and listening prudently.
  Improving Social Interactions Supporting Diversity: It helps tohandle the taskefficiently through exchange of ideas and opinions amongst the group.
- **Strengthening Interpersonal Relationships:** It allows forming symbiotic and trusting relationships which give the team members a sense of belonging and developing interpersonal relationships dealing with conflicts.

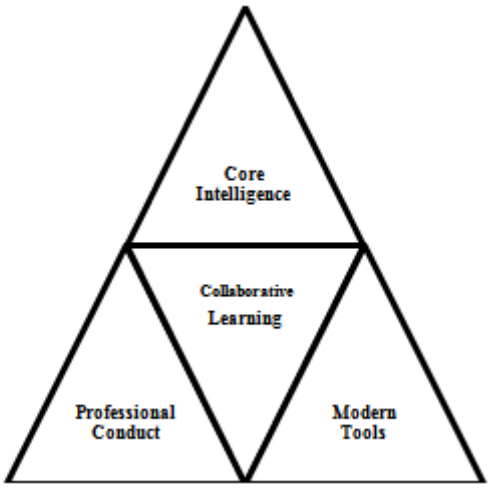

Figure 1: Components of Collaborative Learning

C. Using Modern Tools[7]

- **Usage of ICT:** It expects to implement *Information Communication Tools* as per the industry requirements over the networks**.**
- **Data Handling and Processing:** It offers data handling, processing and report generations as per globally accepted standard norms and benchmarks[8].

III. A CASE Study

To promote the exercise of collaborative learning, an interdisciplinary bridging of domain engineering is suggested. Figure 2 shows the recent guidelines proposed by AICTE *(All India Council for Technical Education)* to define the structure of engineering education in India. It is observed that, significant weightage (≈21%) is given for interdisciplinary course components in the curriculum structure [9].
As a part of case study, few project assignments andits cumulative outcome are observed based on the expected key components that are discussed in Table II and III.

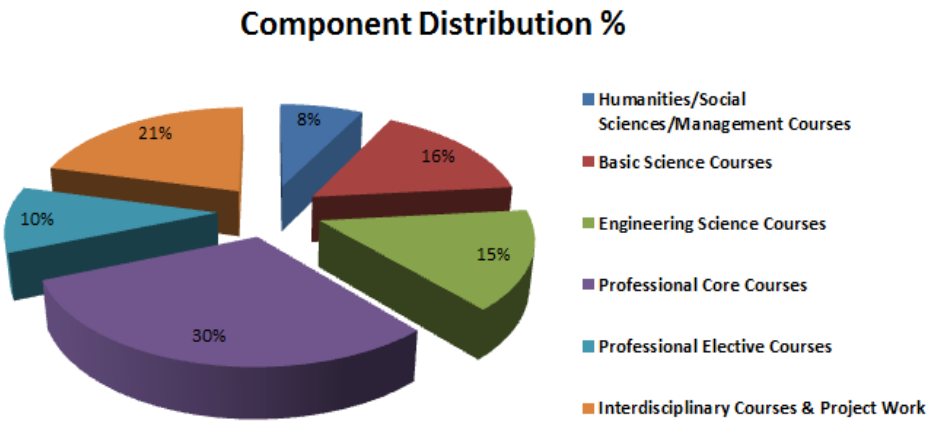

Figure 2: AICTE Guidelines for Curriculum Components

A Sample assignment, *'Irrigation System'* is discussed in figure 3, indicating the components of basic model. However, the extension of the work can be achieved by further additional tasks with the involvement of

multipledomain engineering expertise. The possible extension of the basic model is demonstrated in logical work layers in figure 4.

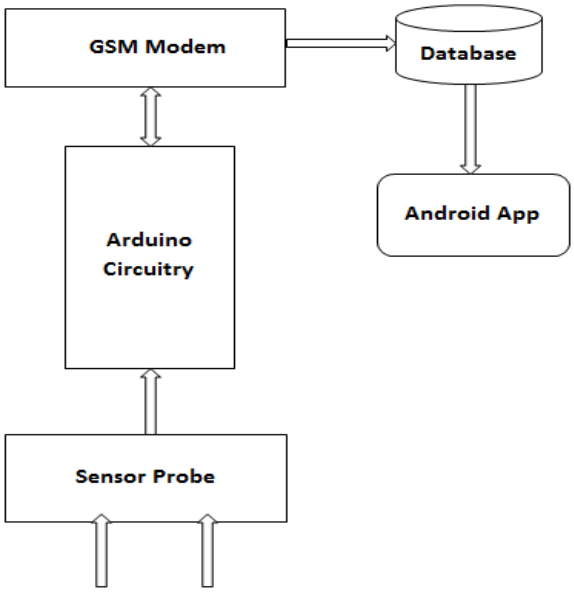

Figure 3: Irrigation System: Basic Model

The layered architecture helps to integrate various components to develop *'Smart Irrigation System'*. The components can be sub layered to manage the lifecycle of the operations for overall execution[10]. In order to achieve interoperability; the coordination amongst the heterogeneous group becomes necessary along with proprietary technology. The provisions of layer components are described as:

Physical Layer enables the probe to sense the moisture (or similar useful parameters) level of the soil. The sense signals are conveyed to Arduino circuitry though output pins.

Device Layer Arduino circuitry receives the input signal from physical layer applying the programming logic to process the signal and convert it to data information.

Interconnection Layer provides the wireless communication medium for transferring data to the server on the Cloud. Interconnection layer connects the physical tier with virtual processing platform.

Aggregation Layer accumulates real data. Database server deals with standard data set with necessary requirements for specific crop and similar category.

Computation Layer provides the platform for the benchmark comparison deciding threshold criteria of the system.

User Layer communicates the inferred results to the end user over mobile device for easy handling and notifications.

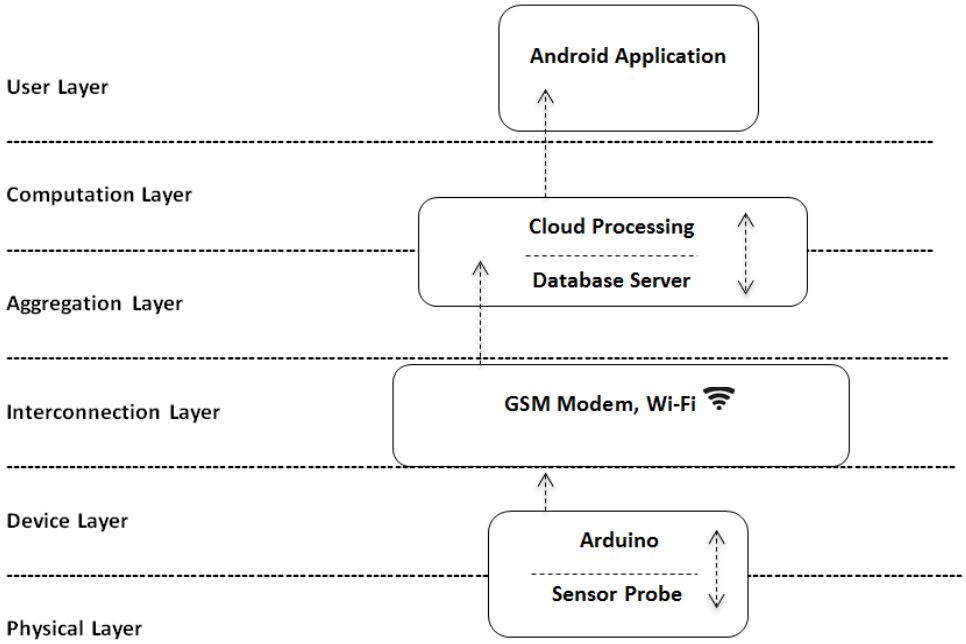

Figure 4: Smart Irrigation System: Layered Architecture

Table I indicates the comparative analysis of the assignment, if it is handled as the part of core domain work or the part of interdisciplinary collaborative work. Few parameters are listed in the table as key issues for the discussion. It can be noted that, the title of the assignment reveals the shift in the paradigm from limited scope of execution to the expanded outline which is divided into logical layers. The course outcome of team assignment is more elaborative as per the Bloom's Taxonomy and its cognitive activity level. Though, both course outcomes are of creation level, the team outcome insists the specific action framedwith the operationalmeans and conditions. In a team, members simulate various roles forming agile system. An integrated team always tries to offer the solution which is simple and easy to operate for any common user maintaining the functionaltransparency[1][3][11].

Table I: Core Vs. Collaborative Learning

Parameters	Core Domain Assignment	Interdisciplinary Team Assignment
Title of Assignment	Irrigation System	Smart Irrigation System
Work Layers Involved	Physical & Device	Physical, Device, Network Interconnect, Data aggregation, Data Computation, User Application etc.
Sample Course Outcome (CO)	To build an IoT system using appropriate devices and gateways	To design an integrated application system using sensors, actuators, wireless network connection, data analytics and necessary control s/w
Components Involved	Factual, Metacognitive	Agile, Automotive
Sense of Learning	Contextual	Reflective
User Interface/ Application Perspective	Involved	Transparent
Instructor/Administrator Perspective	Concentrate knowledge in depth	Expand technologies across breadth

IV. Process Evaluation and Results

If learning outcome is to be assessed through instructor or administrator's perspective, it is required to convert qualitative judgmental analysis of the students' performance into the quantitative index. Table II helps to evaluate the same with calibration description outlined in the form of rubrics [3][8].

Table II: Calibrating Collaborative Learning

Expertise Level → / ***Parameters ↓***		**Proficient**	**Adequate**	**Novice**
Core Skill	Core Knowledge	Gaining expertise in core discipline	Streaming and applying the disciplinary knowledge	Developing the knowledge
	Mathematical Reasoning	Testing hypothesis to the defined parameters	Modeling framework towards problem definitions	Knowing basics of mathematics and proof theory
	Critical Thinking	Working as *Think Tanks* with analytical abilities	Acquiring critical thinking ability with sense of analysis	Involving in relevant brainstorming
Professional Skill	Problem-Solving	Providing optimal or near optimal solutions	Preparing methodologies towards problem solutions	Developing capacities to arrive at solution
	Communication	Convincing the team members with proper communication	Participating actively to listen and discuss	Exchanging the ideas
	Social Interactions	Communicating individual peer in a group	Sharing thoughts to all stake holders	Interacting with peers
	Interpersonal Relationships	Proficiently dealing with conflicts	Adequately dealing with suggestions	Reasonably dealing with opinions
	Self-management	Acquiring leadership/Managerial skills within the team	Developing self to become important entity of the team	Working as team member
Usage of Modern Tool	Usage of ICT	Consistently using the modern tools/ technologies with industry standards and gaining Web Interface expertise	Moderately using the modern tools and Web Interfaces	Trainee using relevant tools
	Data Handling and Processing	Processing data with modern tools and data sets against standard benchmarks generating repots	Processing data with modern tools and variety of data sets	Using conventional data handling platform

Table III lists the marks of 15 teams in a class with individual assignment. The learning evaluation marks are ranked with the metrics stated in the Table II.The class skill attainment is set to some predefined target (e.g. 50%) called as *Attainment Index(AI)*.

Accordingly, the *AI* is calculated for individual skill outcome by using equation 1:

$$Attainment\ Index = \sum_{i=1}^{m} (Skill\_Outcome)_i \ / \ m \text{---------- (Eq.1)}$$

Where, i = 1, 2, 3, -----, m;
m = Total number of teams

Table III: Skill Outcome Attainment

Team No. (3 Students/Team)	Outcomes → / ↓ Assignment	Core Skill (40%)	Professional Skill (30%)	Usage of Modern tools (30%)
1	Weather Monitoring System	30	23	21
2	Smart Irrigation System	28	19	20
3	Office Automation using Passive Infrared Sensor	25	23	17
4	Smart Water Metering System	35	16	8
≈ . .	≈ . .	≈ . .	≈ . .	≈ . .
12	Home Security Model	38	25	19
13	Motion Controlled Servo Mechanism	34	13	10
14	Biometrics using Raspberry Pi	35	24	10
15	Home Automation System Passive Infrared Sensor	37	18	23
	Attainment Index (AI)	**82.7 %**	**60.9 %**	**47.4 %**
	Remark (Target Attainment Index = 50%)	**Excellent**	**Satisfactory**	**Needs to Improve**

A

B

The results of Table III are demonstrated graphically in figure 5. It is observed that, theAI_Core Skill of class is 82.7% which is remarked as 'Excellent' outcome.However, AI_Modern Tools is not up to the target benchmark. Hence, it is applicable to recursive improvement until satisfactory performance.It is further perceived that, team no. 4 is comparatively poor in usage of modern tools which affects data processing, visualization and thus the reliability of the product. The very state is labeled as 'A' in Table III and figure 5.In a similar way, state B reflects the team expertise biasing towards the core skills only.

Similar graphs can be obtained for individual student evaluation. This assessment may be compared with flexible threshold target as well. Thus, the overall impression of the result statistics will be helpful in various ways such as:

- Relative grading of students
- Relative grading of teams as per the assignment category and the thrust area of the research
- Project assignment formulation
- Attainment of K-S-A (Knowledge, Skill, Attitude) attributes
- Attaching affective and psychomotor domain control conditions to the cognitive action
- Setting fuzzy thresholds as per students' background and intake quality
- Deciding testing conditions by finding peak performances through game theory approaches
- Identifying students' comfort level, area of work interestwith required aptitude
- Selecting education streams and hence the carrier profession

etc….

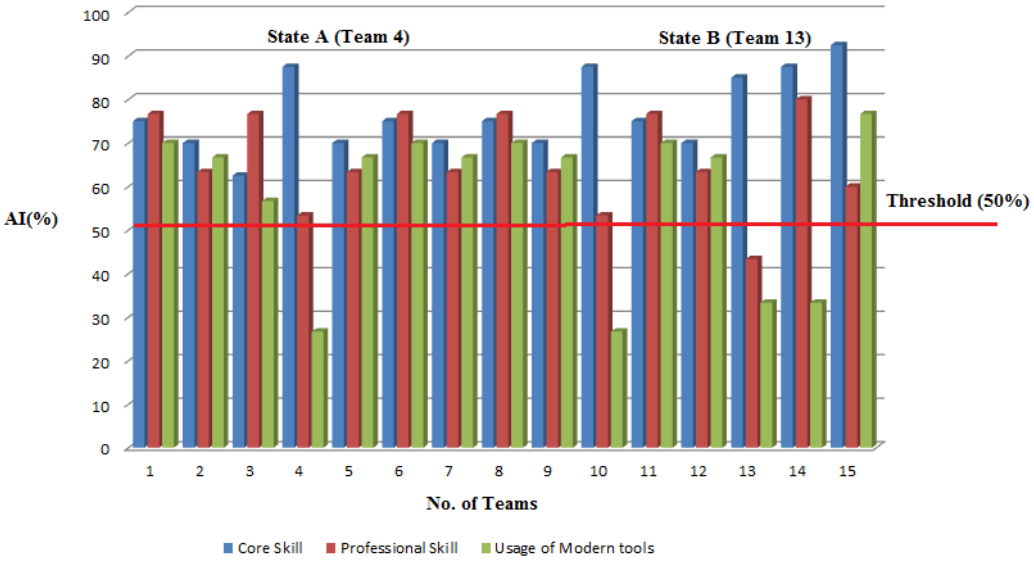

Figure 5: Team Evaluation using AI

V. Remark

As the consequences of a specialized education are becoming more apparent, PBL has been proved as the major pillar of Collaborative Learning. Hence, an engineering education is also encouraging interdisciplinary joint efforts to construct the user friendly product with emerging technological fields. The paper facilitates the significant aspect of collaborative learning in IoT based case studies. The experiment has been carried out to evaluate multi domain intelligence with skill based outcomes. The results obtained help students to introspect and strengthen the required weaker abilities.

The Attainment Index is to be decided by the instructor as per the expectation levels of the outcome skills in terms of core knowledge, professional behavior and its fusion using advanced tools for computational analysis of the work. This will also help in mentoring the students and shape theirtalent to sustain themselves in the competitive world.

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