



Institute of Information Technology University of Dhaka

**Topic: Goal Question Metric (GQM)
Software Metrics (SE-611)**

Submitted to

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An Empirical Evaluation of IITCPC's Effectiveness In Developing A Strong Competitive Programming Culture at IIT

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1. Introduction

GQM, short for "Goal, Question, Metric," is a well-established, goal-driven approach used in software metrics to evaluate and enhance software quality.

It operates across three distinct levels:

- **Conceptual Level (Goal):** At this level, a goal is defined for a specific object. This goal reflects various quality models, serves multiple purposes, considers different perspectives, and is set within a specific context or environment.
- **Operational Level (Question):** A series of questions is formulated to develop models of the object under study. These questions aim to assess or determine the extent to which the defined goal is being achieved.
- **Quantitative Level (Metric):** Each question is paired with one or more measurable metrics, enabling a quantitative evaluation of the object and providing concrete answers to the questions.

The GQM process begins with defining a clear goal that reflects what we aim to evaluate or improve. This goal has to be specific, measurable, and must align with our broader objective of what we want to achieve.

Once the goal is established, we developed a set of focused questions designed to explore various aspects of this goal. Each question is linked to appropriate and measurable metrics to ensure objective and accurate evaluation.

A structured questionnaire is then created using these questions and distributed to the target audience. This helped us collect consistent and relevant data.

In the final stage, the responses gathered are analyzed using appropriate statistical methods for each question. This will help us identify patterns, measure impact, and understand respondents' perceptions.

Finally, we interpreted the results to draw conclusions from our results.

2. Project Specification

2.1 Project Overview

Our objective is to evaluate the effectiveness of the Institute of Information Technology Competitive Programming Club (IITCPC) in developing and promoting a strong competitive programming (CP) culture among students of IIT. Specifically, we aim to measure the awareness, participation, learning experience, and motivation levels of students with respect to competitive programming, and understand how IITCPC has influenced these aspects.

2.2 Motivation

The idea for this project stemmed from a noticeable gap between the CP culture of the CSE department and that of IIT. The CSE department at our university has a well-established competitive programming environment, with students frequently forming teams and getting selected for IUPCs and ICPC. In contrast, despite having talented students, IIT sees significantly lower participation and recognition in such events. IITCPC is the only club within our department focused on competitive programming, and we wanted to assess whether it is effectively inspiring and supporting students to pursue CP seriously. We are particularly interested in knowing how well the club is engaging students, what challenges exist, and whether its initiatives are making a meaningful impact on the students' growth in this field.

2.3 Scope

To evaluate the club's impact, we conducted a survey targeting current first, second, and third-year undergraduate students of IIT. These students are in the early and middle stages of their academic journey, making them the ideal group to assess in terms of CP exposure, motivation, and future potential.

3. Goal Specification

3.1 GQM Framework

General Statement: Evaluating IITCPC's Effectiveness in Developing a Strong Competitive Programming Culture at IIT

3.2 PPE Approach

Purpose: To evaluate the effectiveness of IITCPC (Institute of Information Technology Competitive Programming Club) in cultivating a strong competitive programming (CP) culture within IIT. Specifically, we aim to assess how the club has impacted students' awareness, participation, skill development, motivation, and sense of community in the CP domain.

Perspective: We approach this from the viewpoint of current undergraduate students (1st to 3rd year) who are the primary target group for IITCPC's initiatives. Through this perspective, we examine key dimensions such as students' familiarity with the club, their level of engagement in its events, perceived improvements in their CP abilities, and the support they receive through mentorship, learning resources, and peer collaboration.

Environment: Our study is set within the academic environment of the Institute of Information Technology, where participation in national and international programming contests (e.g., IUPC, ICPC) is a major benchmark of CP engagement. Unlike the CSE department, where CP is deeply embedded in the student culture, IIT's CP involvement is still in a developing phase. This makes it essential to understand how students in this particular environment perceive IITCPC's role and effectiveness.

After defining our focus using the Purpose–Perspective–Environment (PPE) framework, our final goal is:

“To evaluate the awareness, participation, support structures, and perceived impact of IITCPC among undergraduate students of IIT, with the aim of understanding its effectiveness in fostering a competitive programming culture.”

3.3 Subgoals

Our main goal is to evaluate IITCPC's effectiveness in fostering a strong competitive programming (CP) culture at IIT. To break this down, we have identified the following subgoals:

- A.** Assess students' awareness and understanding of IITCPC and its activities.
- B.** Measure the level of participation in IITCPC events and initiatives.

- C.** Evaluate IITCPC's perceived impact on students' CP skills, motivation, and confidence.
- D.** Understand the accessibility, inclusivity, and support provided by IITCPC for learners at different levels.
- E.** Explore the sense of community and communication fostered by IITCPC among IIT students.

3.4 Questions and Metrics

3.4.1 Subgoal A: Assess students' awareness and understanding of IITCPC and its activities

Q1: Are you aware of IITCPC and its activities?

- **M1:** Percentage of students responding "Yes"
- **M2:** Number of students aware vs. not aware

Q2: How did you first learn about IITCPC?

- **M1:** Frequency distribution of response categories (e.g., Seniors/Peers, IITCPC members, Online, Others)

Q3: What activities does IITCPC organize (as recognized by students)?

- **M1:** Frequency of each activity selected (Contest, Programming Session, Peer Discussion, Workshop)

3.4.2 Subgoal B: Measure the level of participation in IITCPC events and initiatives

Q1: How frequently do you participate in IITCPC-organized events?

- **M1:** Distribution across frequency categories (Never, Rarely, Occasionally, Frequently)

Q2: What types of IITCPC events have you participated in?

- **M1:** Frequency distribution of students selecting each type of event
- **M2:** Number of event types attended per student

Q3: How many IITCPC events have you attended in the past year?

- **M1:** Frequency distribution of number of events attended

3.4.3 Subgoal C: Evaluate IITCPC's perceived impact on CP skills, motivation, and confidence

Q1: To what extent has IITCPC improved your CP skills?

- **M1:** Distribution of ratings (1 to 4)
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q2: How motivated are you to improve your CP skills due to IITCPC?

- **M1:** Motivation rating distribution (1 to 4)
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q3: Has IITCPC increased your confidence to participate in contests (e.g., ICPC)?

- **M1:** Confidence rating distribution (1 to 4)
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q4: How consistent are you in practicing CP due to IITCPC initiatives?

- **M1:** Agreement scale distribution (1 to 5)
- **M2:** Grouped proportions (Low = 1–2, High = 3–5)

3.4.4 Subgoal D: Understand the accessibility, inclusivity, and support provided by IITCPC

Q1: How helpful are IITCPC's learning resources?

- **M1:** Distribution of helpfulness ratings
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q2: How accessible are IITCPC's resources/events for all skill levels?

- **M1:** Accessibility rating distribution
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q3: How adequate is IITCPC's mentorship for beginner programmers?

- **M1:** Adequacy rating distribution
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q4: How frequently does IITCPC organize workshops or training sessions?

- **M1:** Distribution of perceived frequency ratings
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

3.4.5 Subgoal E: Explore the sense of community and communication fostered by IITCPC

Q1: How effectively does IITCPC communicate about events and opportunities?

- **M1:** Communication rating distribution
- **M2:** Grouped proportions (Low = 1–2, High = 3–4)

Q2: Have you formed study groups, teams, or discussion circles through IITCPC?

- **M1:** Percentage of students responding "Yes"

Q3: Does IITCPC foster collaboration, competition, or both?

- **M1:** Distribution of perception responses
- **M2:** Grouped proportions (Low = 1–2, High = 3–5)

Q4: How satisfied are you with IITCPC's efforts to build an inclusive CP community?

- **M1:** Satisfaction rating distribution
- **M2:** Average satisfaction score by event participants vs. non-participant

4. Data Collection and Visualization

This report was prepared using data collected from undergraduate students of the Institute of Information Technology (IIT), particularly from the 1st, 2nd, and 3rd-year cohorts. These students were specifically chosen because they are the key target group for IITCPC's competitive programming initiatives, and their engagement and perceptions are most relevant to the current state and future of CP culture within IIT.

To support our investigation, we carefully designed a survey questionnaire that covers multiple dimensions related to competitive programming and IITCPC's influence. These include awareness of the club, participation in its events, perceived improvement in skills and motivation, accessibility of learning resources, and the sense of community it fosters.

4.1 Demographic Information:

We collected limited demographic information, focusing primarily on students' year of study, as it is a relevant factor in understanding their level of exposure to CP and to IITCPC activities. Our aim was not to compare individuals but to analyze broader patterns across academic years.

The full questionnaire can be accessed here: <https://forms.gle/Ryh4Whg7FfxGhdRm8>

4.2 Data Visualization

The summary of the collected data is presented here in graphs and charts:

4.2.1 Demographic:

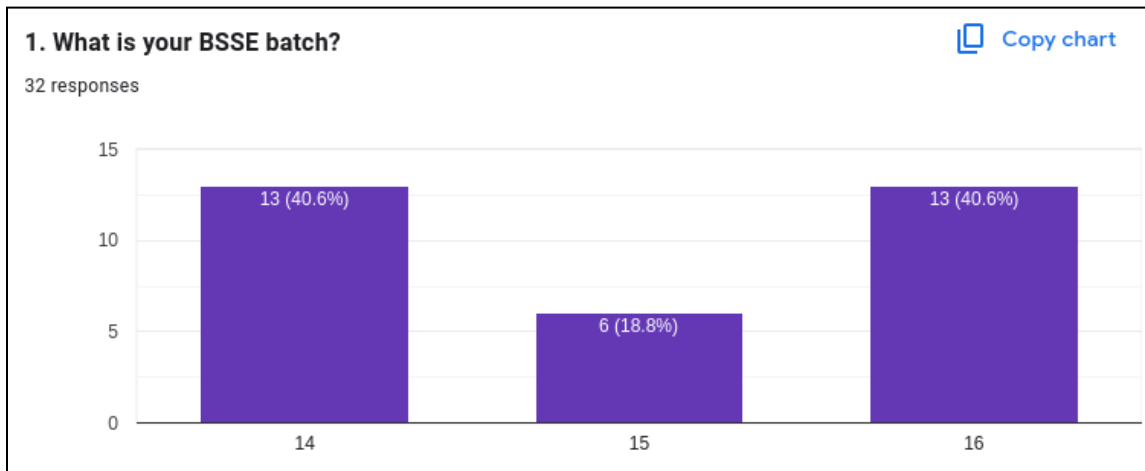


Fig 1: Respondents' BSSE batch

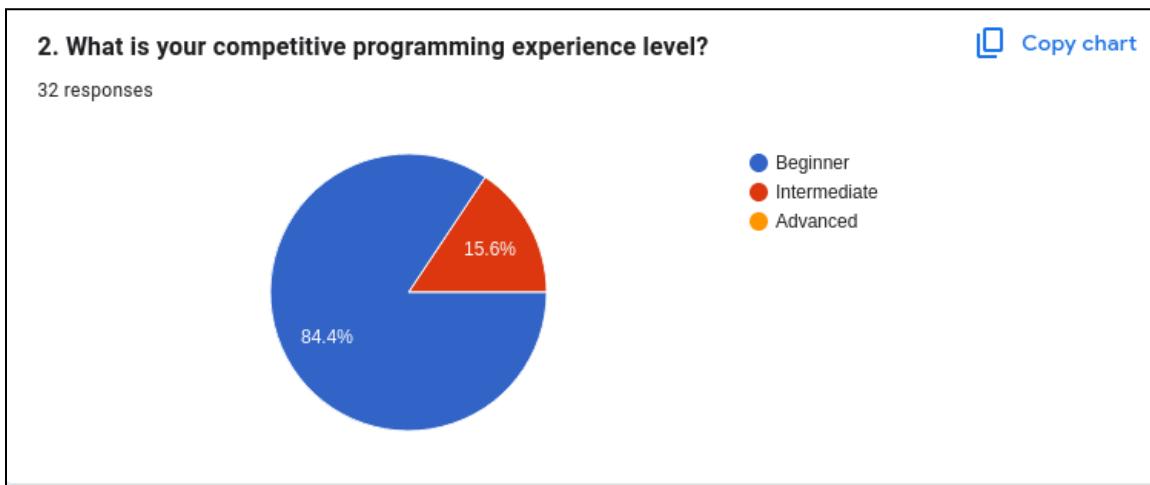


Fig 2: Respondents' experience in competitive programming

4.2.2 Relating to IITCPC awareness:

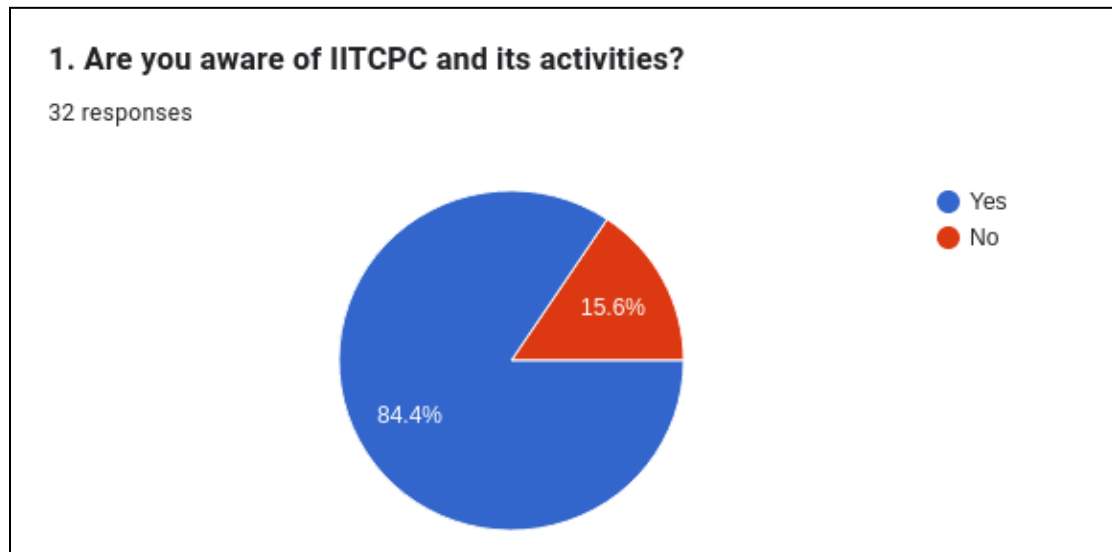


Fig 3: Respondents' awareness of IITCPC and its activities

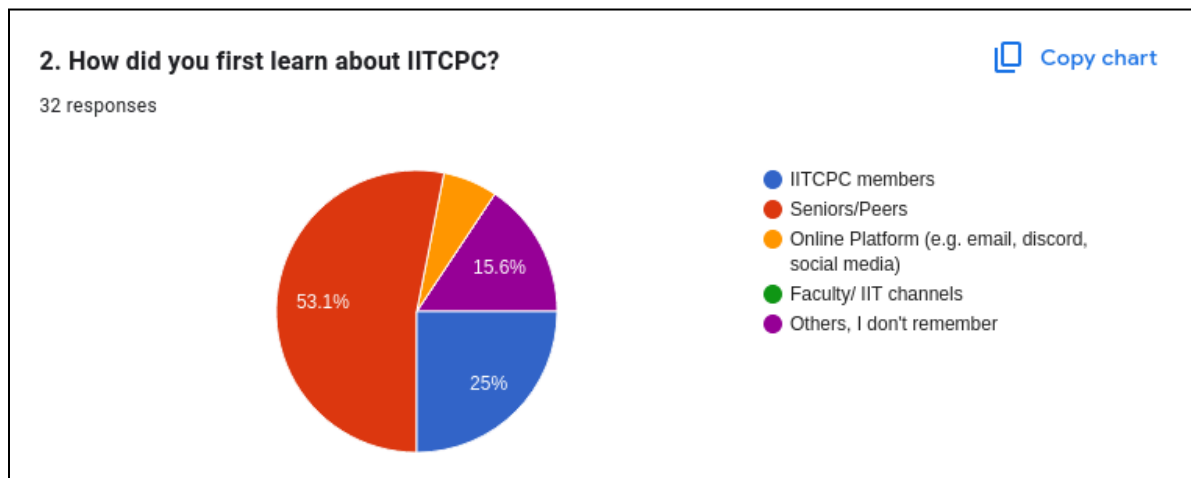


Fig 4: Respondents' Initial Source of Awareness About IITCPC

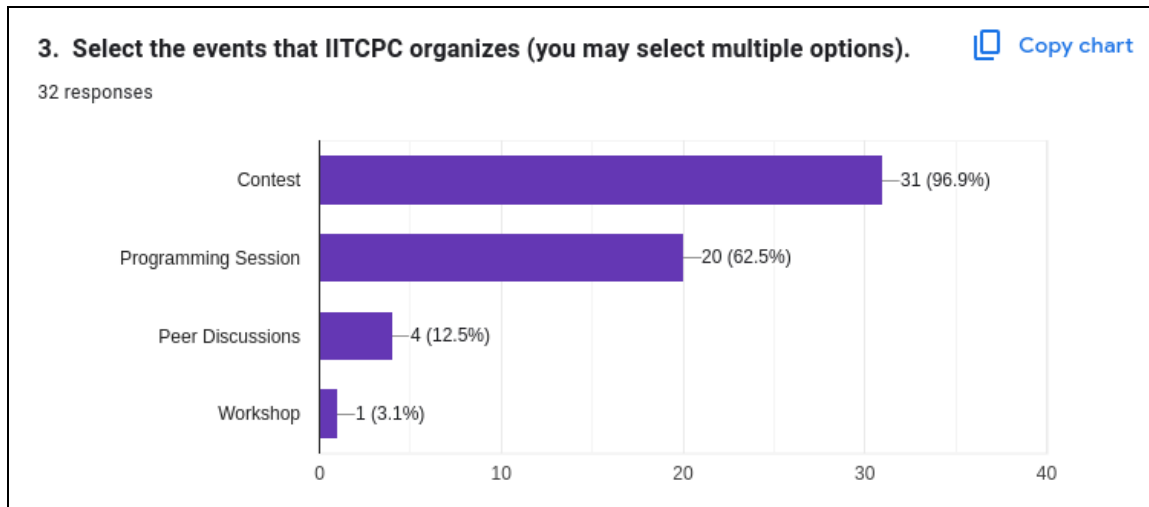


Fig 5: Respondents' awareness of events organized by IITCPC

4.2.3 Relating to participation:

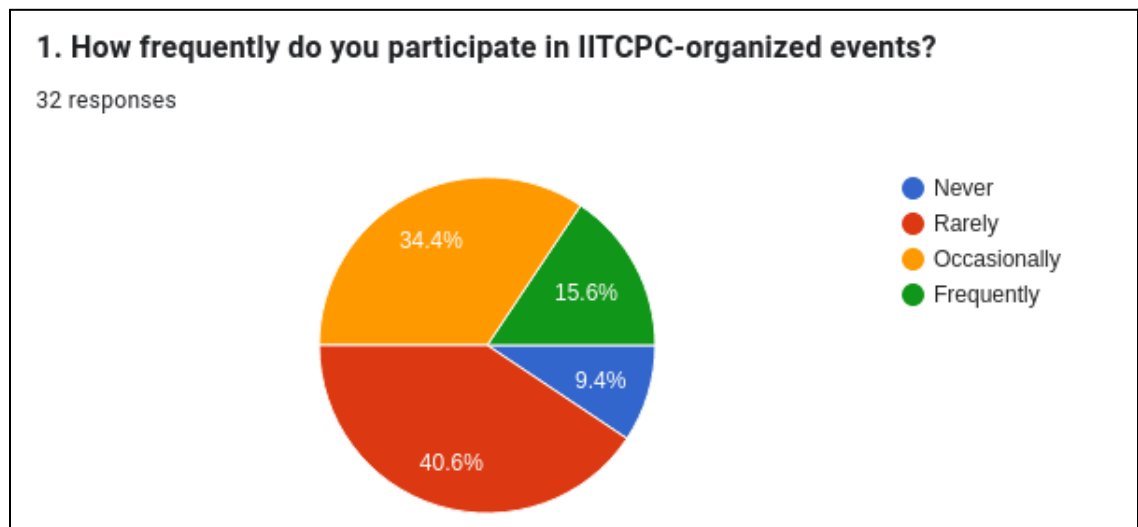


Fig 6: Participation Frequency of Respondents in IITCPC Events

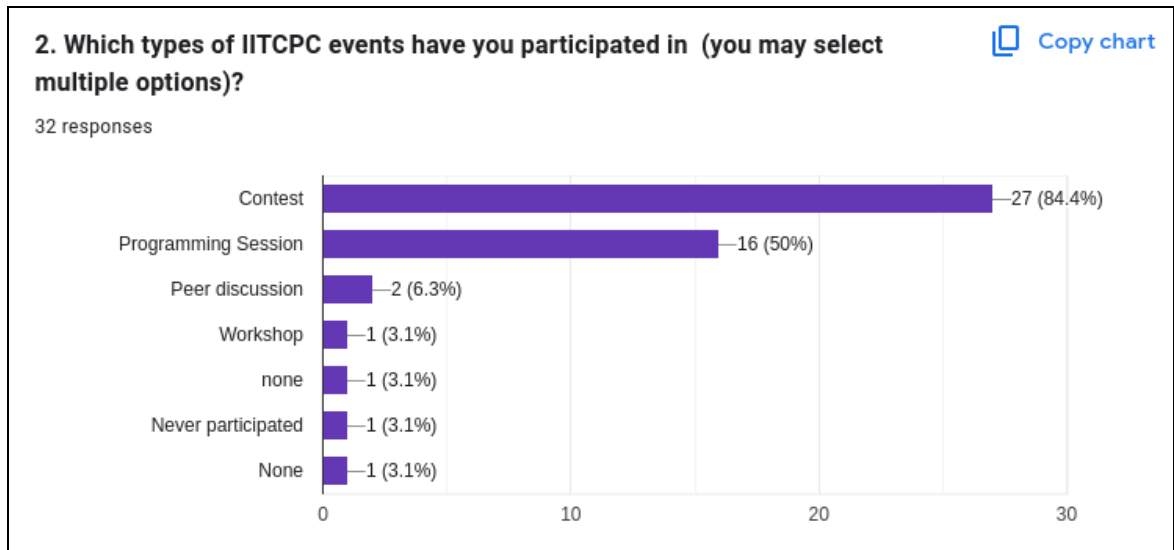


Fig 7: Type of IITCPC events respondents participate in

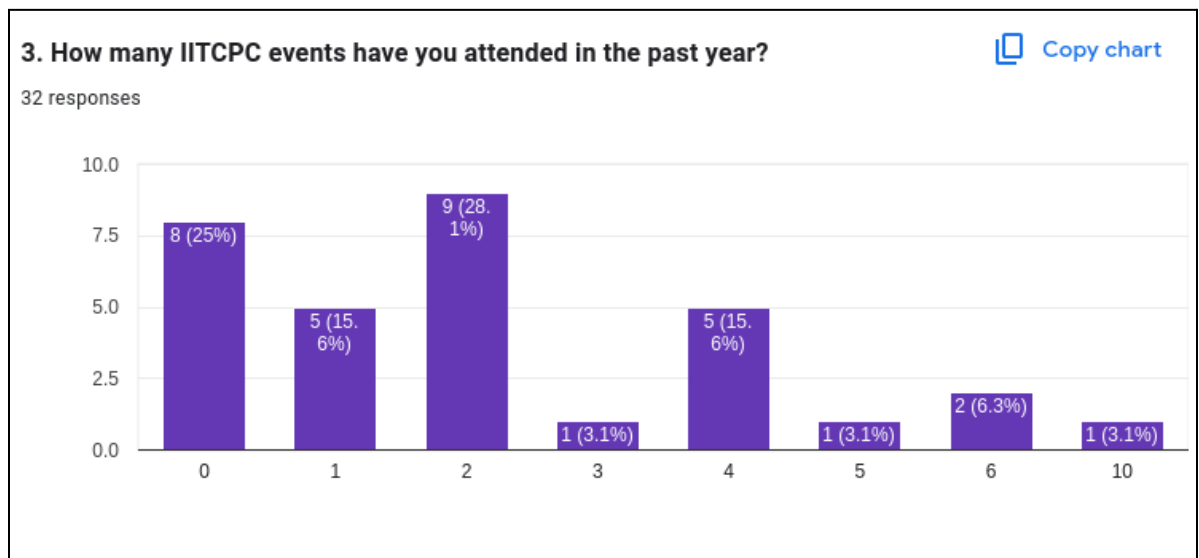


Fig 8: Number of IITCPC events attended by respondents

4.2.4 Relating to skill development:

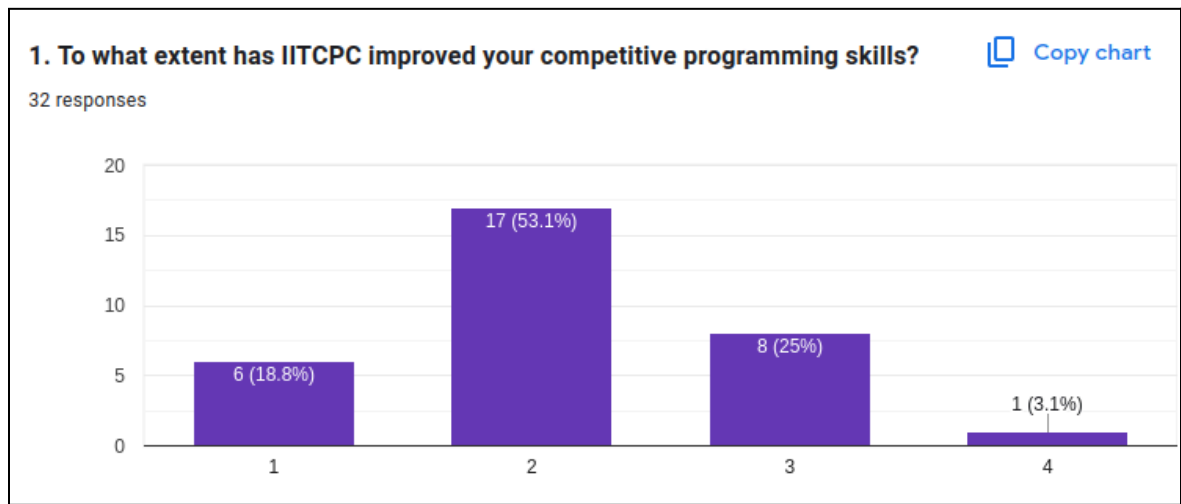


Fig 9: Impact of IITCPC on respondents' CP skill development

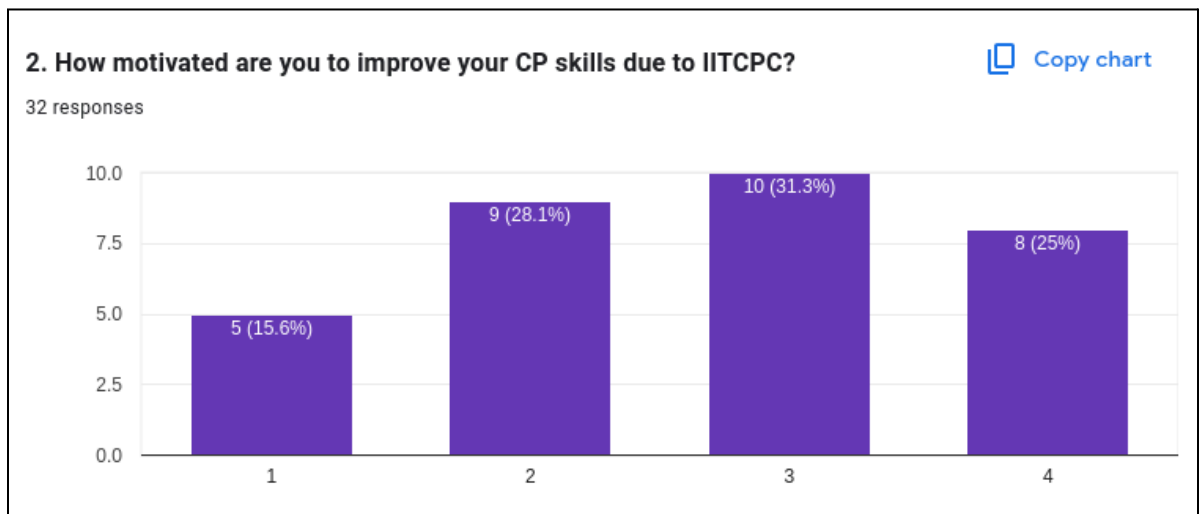


Fig 10: Respondents' motivation to improve CP skills due to IITCPC4

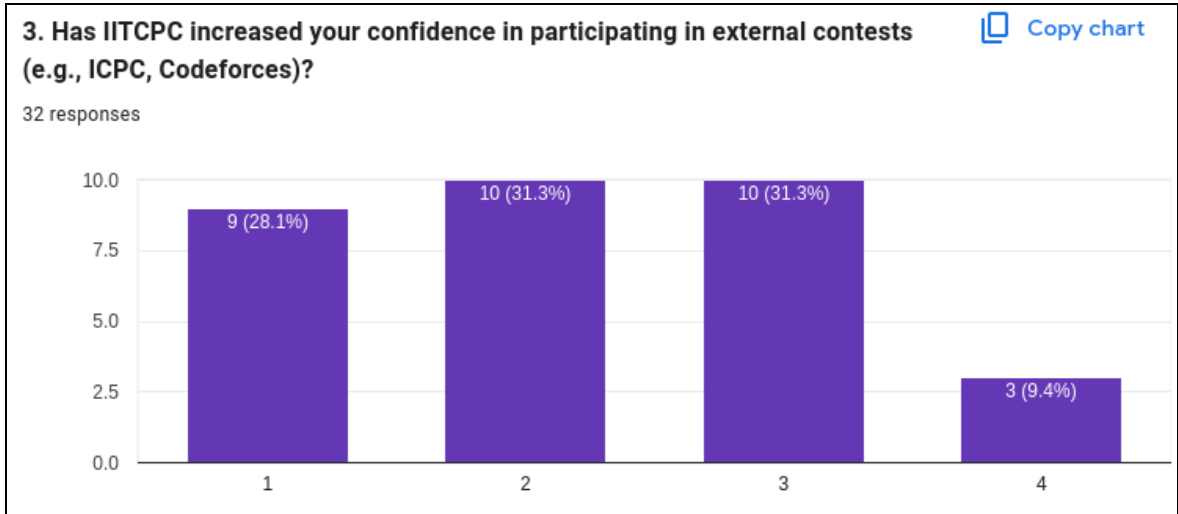


Fig 11: Respondents' confidence in participating in external contests due to IITCPC

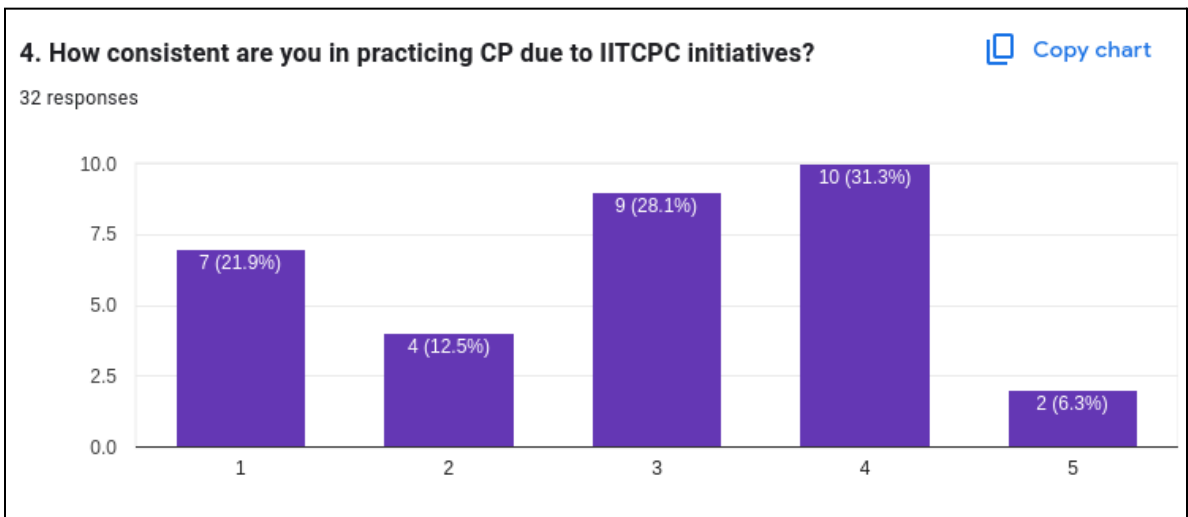


Fig 12: Respondents' consistency in practicing CP due to IITCPC initiatives

4.2.5 Relating to Accessibility and Support

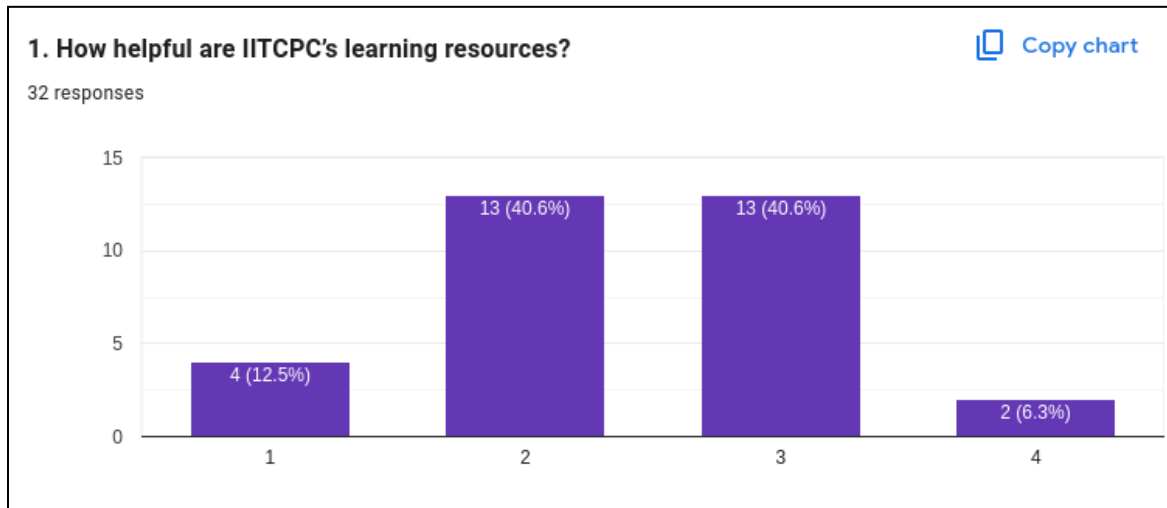


Fig 13: Helpfulness of IITCPC learning resources to respondents

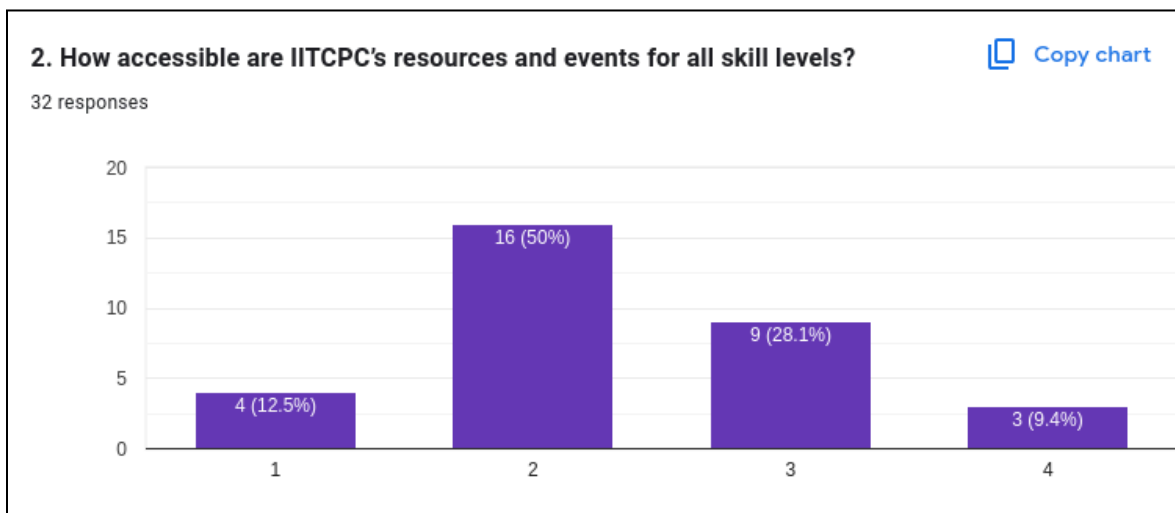


Fig 14: Accessibility of IITCPC resources and event for respondents of all skill levels

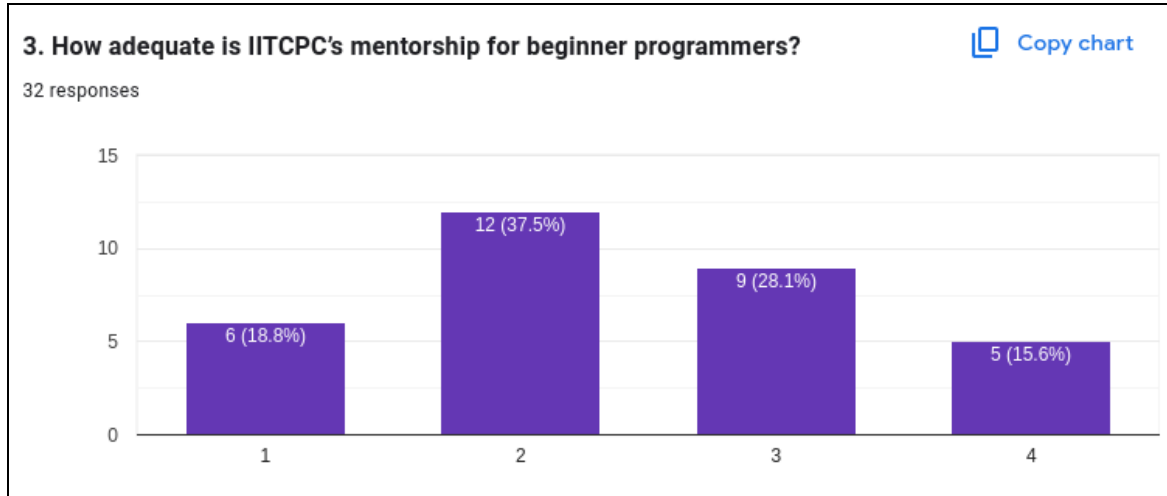


Fig 15: Respondents' evaluation of mentorship support from IITCPC for beginners

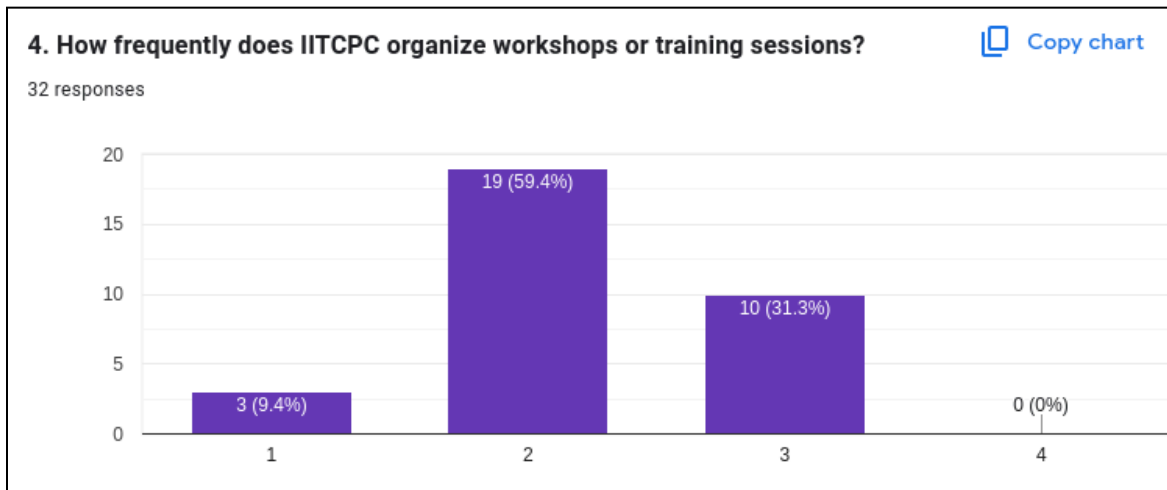


Fig 16: Frequency of different event organization by IITCPC

4.2.6 Relating to Community and Communication:

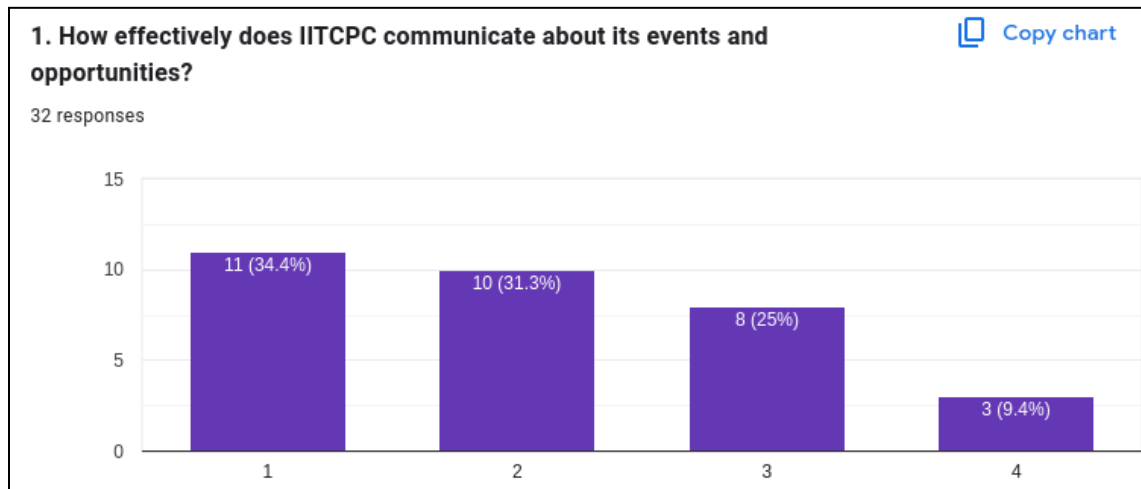


Fig 17: Effectiveness of IITCPC's event and opportunity communication

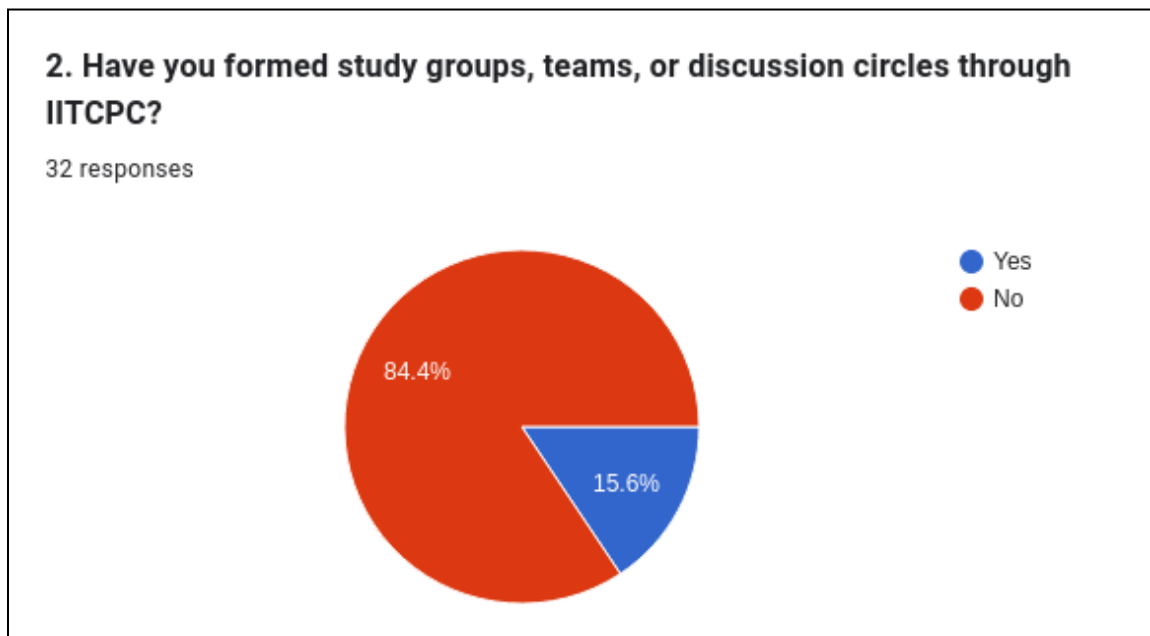


Fig 18: Respondents' engagement in peer learning through IITCPC

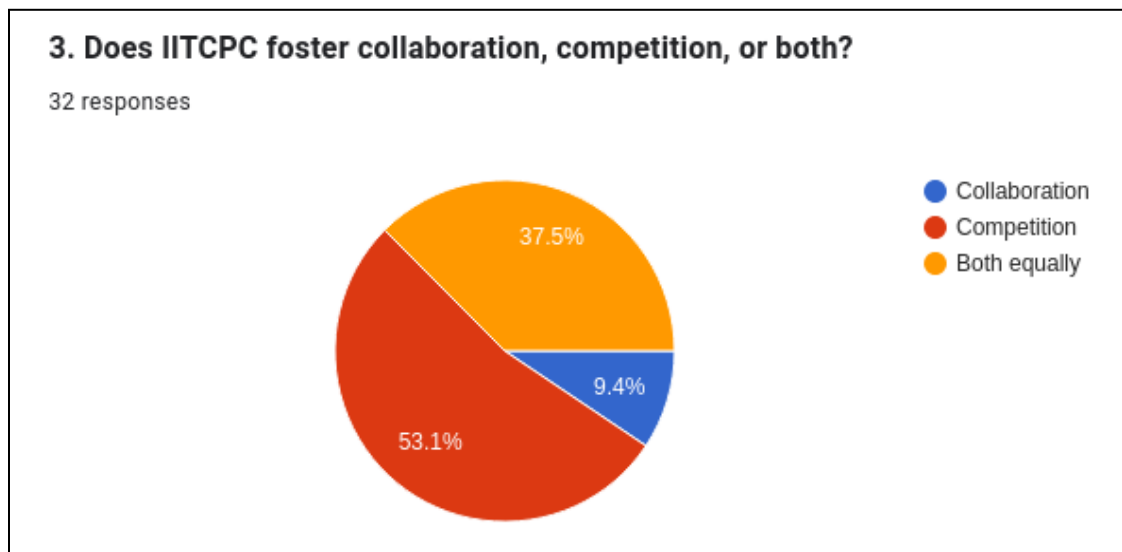


Fig 19: Respondents' views on the nature of engagement promoted by IITCPC

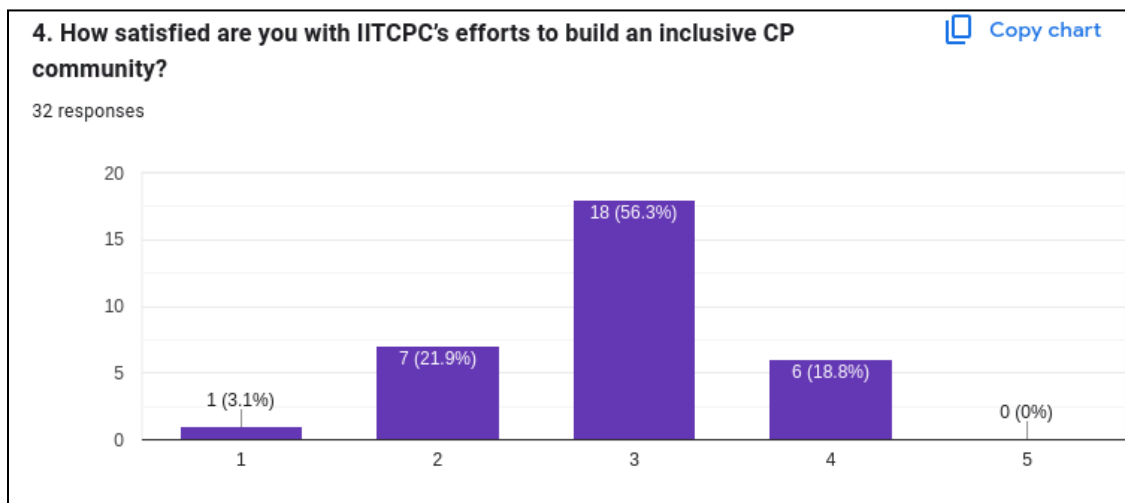


Fig 20: Respondents' satisfaction with IITCPC's efforts to build inclusive CP community

5. Metric Analysis

5.1 Subgoal A: Assess students' awareness and understanding of IITCPC and its activities

Question 1: Are you aware of IITCPC and its activities?

Null Hypothesis (H_0):

The proportion of students aware of IITCPC is 50% or less ($p \leq 0.5$).

Calculation:

| Variable | Value |
|---------------------------------|--|
| Sample size (n) | 32 |
| Number of "Yes" (x) | 27 |
| Sample proportion (\hat{p}) | $27 / 32 = 0.844$ |
| Null proportion (p_0) | 0.5 |
| Standard error (SE) | $\sqrt{\frac{p_0(1-p_0)}{n}} = 0.0884$ |
| Test statistic (z) | $\frac{(\hat{p} - p_0)}{SE} = 3.89$ |

The calculated z-value is 3.89, which corresponds to a p-value less than 0.0001. Since the p-value is less than the significance level of 0.05, we reject the null hypothesis.

Decision on H_0 :

We reject the null hypothesis — there is sufficient evidence to conclude that the proportion of students aware of IITCPC is greater than 50%.

Conclusion:

The survey results show that 84.4% of respondents are aware of IITCPC and its activities. This indicates a strong awareness level among students, supporting the effectiveness of IITCPC's outreach efforts.

Question 2: How did you first learn about IITCPC?**Null Hypothesis (H_0):**

The responses are uniformly distributed across the categories (i.e., students learn about IITCPC equally from all sources).

Calculation:

| Source | O | E | $\frac{(O - E)^2}{E}$ |
|---------------------------|----|---|-----------------------|
| Seniors/Peers | 17 | 8 | 10.125 |
| IITCPC members | 8 | 8 | 0 |
| Others / I don't remember | 5 | 8 | 1.125 |
| Online Platforms | 2 | 8 | 4.5 |
| Sum | | | 15.75 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 4 - 1 = 3$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 3 df ≈ 7.815

Calculated chi-square = 15.75 > 7.815 \rightarrow p-value < 0.01

Decision on H_0 :

Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

There is a statistically significant difference in how students first learned about IITCPC. The data shows Seniors/Peers are the dominant source of initial awareness, far more than other channels. Online platforms are the least cited. This highlights the strong influence of informal peer networks in outreach and suggests online visibility may need improvement.

Question 3: Select the events that IITCPC organizes (you may select multiple options).

This question allowed multiple responses, so the test was conducted on the **aggregate frequencies** of each event type selected, not per respondent.

Null Hypothesis (H_0):

Students recognize all IITCPC event types equally (uniform distribution of selections).

Calculation:

| Event | O | E | $\frac{(O - E)^2}{E}$ |
|---------------------|----|-------|------------------------------------|
| Contest | 32 | 14.25 | $(17.75)^2 / 14.25 \approx 22.11$ |
| Programming Session | 20 | 14.25 | $(5.75)^2 / 14.25 \approx 2.32$ |
| Peer Discussions | 4 | 14.25 | $(-10.25)^2 / 14.25 \approx 7.38$ |
| Workshop | 1 | 14.25 | $(-13.25)^2 / 14.25 \approx 12.33$ |
| Sum | | | 44.14 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 4 - 1 = 3$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 3 df ≈ 7.815

Calculated chi-square = 44.14 > 7.815 \rightarrow p-value < 0.01

Decision on H_0 :

Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

There is strong statistical evidence that some IITCPC event types are significantly more recognized than others. In particular, "Contest" and "Programming Session" are far more recognized compared to "Peer Discussions" or "Workshop".

5.2 Subgoal B: Measure the level of participation in IITCPC events and initiatives

Question 4: How frequently do you participate in IITCPC-organized events?

Null Hypothesis (H_0):

Students are equally likely to participate at all frequency levels — i.e., the responses are uniformly distributed among *Never*, *Rarely*, *Occasionally*, *Frequently*.

Calculation:

| Level | O | E | $\frac{(O - E)^2}{E}$ |
|--------------|----|---|-----------------------|
| Rarely | 13 | 8 | 3.125 |
| Occasionally | 11 | 8 | 1.125 |
| Frequently | 5 | 8 | 1.125 |
| Never | 3 | 8 | 3.125 |
| Sum | | | 8.5 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 4 - 1 = 3$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 3 df ≈ 7.815

Calculated chi-square = $8.5 > 7.815 \rightarrow p\text{-value} < 0.01$

Decision on H_0 :

Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

Participation in IITCPC events is not uniformly distributed. A majority of students reported participating rarely or occasionally, while frequent or no participation is less common. This suggests that while IITCPC events do have reach, consistent and frequent engagement may be limited among students.

Question 5: Which types of IITCPC events have you participated in (you may select multiple options)?

This question allowed multiple responses, so the test was conducted on the **aggregate frequencies** of each event type selected, not per respondent.

Null Hypothesis (H_0):

Students have participated equally in all types of IITCPC events.

Calculation:

| Event Type | Observed (O) | Expected (E) | $\frac{(O - E)^2}{E}$ |
|---------------------|--------------|--------------|--------------------------------|
| Contest | 27 | 9.8 | $(17.2)^2 / 9.8 \approx 30.20$ |
| Programming Session | 16 | 9.8 | $(6.2)^2 / 9.8 \approx 3.92$ |
| Peer Discussion | 2 | 9.8 | $(-7.8)^2 / 9.8 \approx 6.21$ |
| Workshop | 1 | 9.8 | $(-8.8)^2 / 9.8 \approx 7.90$ |

| | | | |
|-----------------------|---|-----|-------------------------------|
| None/No Participation | 3 | 9.8 | $(-6.8)^2 / 9.8 \approx 4.72$ |
| Sum | | | 52.95 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 4 - 1 = 3$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 3 df ≈ 7.815

Calculated chi-square = 52.95 > 7.815 \rightarrow p-value < 0.01

Decision on H_0 : Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

Participation is significantly higher for Contests and Programming Sessions, while Workshops and Peer Discussions are reported at much lower rates. This indicates that although the club organizes a variety of events, student engagement is concentrated around contests and sessions.

Question 6: How many IITCPC events have you attended in the past year?

Null Hypothesis (H_0):

The number of IITCPC events attended by students is evenly distributed across the three attendance categories: low (0–3 events), medium (4–6 events), and high (7 or more events).

Calculation:

| Group | Observed (O) | Expected (E) | $\frac{(O - E)^2}{E}$ |
|------------|--------------|--------------|----------------------------|
| Low | 23 | 11 | $(23 - 11)^2 / 11 = 13.09$ |
| Medium | 9 | 11 | $(9 - 11)^2 / 11 = 0.36$ |
| High | 1 | 11 | $(1 - 11)^2 / 11 = 9.09$ |
| Sum | | | 22.54 |

Degrees of Freedom: $df = 3 - 1 = 2$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 2 df ≈ 5.991

Calculated chi-square = 22.54 > 5.991 \rightarrow p-value < 0.01

Decision on H_0 : Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

The chi-square test indicates a statistically significant difference in the distribution of event attendance across the three categories. A large proportion of students reported attending few IITCPC events (0–3), while far fewer participated frequently (7 or more events). This uneven distribution suggests that while some students actively engage with the club's activities, overall participation remains concentrated in the lower attendance group, highlighting potential areas for increasing student involvement in competitive programming events.

5.3 Subgoal C: Evaluate IITCPC's perceived impact on CP skills, motivation, and confidence

Question 7: To what extent has IITCPC improved your competitive programming skills?

Null Hypothesis (H_0):

Students are equally likely to perceive IITCPC's impact on their CP skills as Low (1,2) or High (3,4).

Calculation:

| Group | Observed (O) | Expected (E) | $\frac{(O - E)^2}{E}$ |
|-------|--------------|--------------|-----------------------|
| Low | 23 | 16 | $(7)^2 / 16 = 3.06$ |
| High | 9 | 16 | $(-7)^2 / 16 = 3.06$ |
| Sum | | | 6.13 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841

Calculated chi-square = 6.13 > 3.841 \rightarrow p-value < 0.01

Decision on H_0 :

Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

This suggests that students do not rate the club's impact uniformly — the majority rated the impact as Low (1–2). This indicates that while IITCPC has had some effect, most students do not feel it has significantly improved their competitive programming skills.

Question 8: How motivated are you to improve your CP skills due to IITCPC?

Null Hypothesis (H_0):

Students are equally likely to report Low (1–2) or High (3–4) motivation due to IITCPC.

Calculation:

| Group | Observed (O) | Expected (E) | $\frac{(O - E)^2}{E}$ |
|-------|--------------|--------------|-----------------------|
| Low | 14 | 16 | $(-2)^2 / 16 = 0.25$ |
| High | 18 | 16 | $(2)^2 / 16 = 0.25$ |
| Sum | | | 0.50 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841

Calculated chi-square = 0.5 > 3.841 \rightarrow p-value > 0.05

Decision on H_0 :

Since $p > 0.05$, we do not reject the null hypothesis.

Conclusion:

The data suggests no significant difference between students reporting low versus high motivation. This means that student opinions are fairly evenly split, and IITCPC's influence on student motivation appears to be neutral — it has not strongly increased motivation across the student body, but neither has it been ineffective.

Question 9: Has IITCPC increased your confidence in participating in external contests (e.g., ICPC, Codeforces)?**Null Hypothesis (H_0):**

Students are equally likely to report low(1,2) or high(3,4) confidence due to IITCPC.

Calculation:

| Group | Observed (O) | Expected (E) | $\frac{(O - E)^2}{E}$ |
|------------|--------------|--------------|------------------------|
| Low | 19 | 16 | $(3)^2 / 16 = 0.5625$ |
| High | 13 | 16 | $(-3)^2 / 16 = 0.5625$ |
| Sum | | | 1.125 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841
 Calculated chi-square = $1.125 < 3.841 \rightarrow p\text{-value} > 0.05$

Decision on H_0 :

Since $p > 0.05$, we do not reject the null hypothesis.

Conclusion:

The difference between students with low and high confidence is not statistically significant. This means we fail to reject the null hypothesis. This means we cannot confidently say that IITCPC has either a strong positive or negative impact on students' confidence. The responses are somewhat evenly spread, suggesting that while IITCPC may help some students feel more confident, it has not yet built widespread confidence across the student body.

Question 10: How consistent are you in practicing CP due to IITCPC initiatives?

Null Hypothesis (H_0):

Students are equally likely to report low(1-2) or high(3-5) consistency in CP practice due to IITCPC.

Calculation:

| Group | Observed (O) | Expected (E) | $\frac{(O - E)^2}{E}$ |
|--------------|---------------------|---------------------|------------------------|
| Low | 11 | 16 | $(-5)^2 / 16 = 1.5625$ |
| High | 21 | 16 | $(5)^2 / 16 = 1.5625$ |
| Sum | | | 3.125 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841
 Calculated chi-square = 3.125 < 3.841 \rightarrow p-value > 0.05

Decision on H_0 :

Since $p > 0.05$, we do not reject the null hypothesis.

Conclusion:

The statistical test shows no significant difference between students who reported low consistency and those who reported high consistency in practicing competitive programming due to IITCPC initiatives. This suggests that IITCPC's impact on encouraging regular practice varies among students, with opinions fairly evenly split. While some students find IITCPC's efforts helpful for staying consistent, others have not been significantly influenced.

5.4 Subgoal D: Understand the accessibility, inclusivity, and support provided by IITCPC

Question 11: How helpful are IITCPC's learning resources?

Null Hypothesis (H_0):

There is no difference in how many students find IITCPC resources low(1-2) vs. highly(3-4) helpful.

Calculation:

| Group | O | E | $\frac{(O - E)^2}{E}$ |
|-------|----|----|-----------------------|
| Low | 17 | 16 | $(1^2)/16 = 0.0625$ |
| High | 15 | 16 | $(1^2)/16 = 0.0625$ |
| Sum | | | 0.125 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841

Calculated chi-square = $0.125 < 3.841 \rightarrow p\text{-value} > 0.05$

Decision on H_0 :

Since $p > 0.05$, we do not reject the null hypothesis.

Conclusion:

The chi-square test shows no statistically significant difference between students who found IITCPC's learning resources less helpful and those who found them more helpful. While a slightly larger portion of students fell into the "low helpfulness" group, the difference was not

strong enough to be considered statistically meaningful. This result suggests that students are divided in their perception of the usefulness of IITCPC's learning materials—some find them moderately or very helpful, while others feel they offer limited support.

Question 12: How accessible are IITCPC's resources and events for all skill levels?

Null Hypothesis (H₀):

There is no significant difference in student responses regarding the accessibility of IITCPC's resources and events for different skill levels — students are equally likely to report low(1-2) or high accessibility.

Calculation:

| Group | O | E | $\frac{(O - E)^2}{E}$ |
|--------------|----------|----------|-----------------------|
| Low | 20 | 16 | $(4^2)/16 = 1.0$ |
| High | 12 | 16 | $(-4)^2/16 = 1.0$ |
| Sum | | | 2.0 |

Degrees of Freedom: $df = \text{Number of categories} - 1 = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841

Calculated chi-square = 2.0 < 3.841 \rightarrow p-value > 0.05

Decision on H₀:

Since $p > 0.05$, we do not reject the null hypothesis.

Conclusion:

The chi-square test shows no statistically significant difference between students who rated IITCPC's resources and events as low in accessibility versus those who rated them as highly accessible. Although a larger number of students fell into the "low accessibility" group, this

difference is not statistically meaningful. The result suggests that student perceptions of accessibility are fairly balanced, but the notable lean toward lower ratings highlights a possible need for improvement in how well the club supports students across varying skill levels.

Question 13: How adequate is IITCPC's mentorship for beginner programmers?

Null Hypothesis (H_0):

There is no significant difference in student perception of IITCPC's mentorship adequacy for beginner programmers — students are equally likely to rate it low(1-2) or high(3-4).

Calculation:

| Group | O | E | $\frac{(O - E)^2}{E}$ |
|------------|----|----|-----------------------|
| Low | 18 | 16 | $(2^2)/16 = 0.25$ |
| High | 14 | 16 | $(-2)^2/16 = 0.25$ |
| Sum | | | 0.5 |

Degrees of Freedom:

$$df = 2 - 1 = 1$$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841

Calculated chi-square = 0.5 < 3.841 \rightarrow p-value > 0.05

Decision on H_0 :

Since $p > 0.05$, we do not reject the null hypothesis.

Conclusion:

The chi-square test indicates no statistically significant difference between students who rated IITCPC's mentorship as low in adequacy and those who rated it as high. While more students leaned toward the "low adequacy" group, the difference is not large enough to be statistically

meaningful. This suggests that perceptions are fairly balanced, though the slight skew implies that some improvement in mentorship for beginners may be beneficial.

Question 14: How frequently does IITCPC organize workshops or training sessions?

Null Hypothesis (H_0):

There is no significant difference in students' responses regarding how frequently IITCPC organizes workshops — students are equally likely to report low(1-2) or high(3-4) frequency.

Calculation:

| Group | O | E | $\frac{(O - E)^2}{E}$ |
|--------------|----------|----------|-----------------------|
| Low | 22 | 16 | $(6^2)/16 = 2.25$ |
| High | 10 | 16 | $(-6)^2/16 = 2.25$ |
| Sum | | | 4.5 |

Degrees of Freedom: $df=2-1=1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841

Calculated chi-square = 4.5 > 3.841 \rightarrow p-value < 0.05

Decision on H_0 :

Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

The chi-square test reveals a statistically significant difference in student responses. A majority of students believe IITCPC organizes workshops rarely or never, with almost no students perceiving them as frequent. This indicates a clear perception that workshops and training sessions are not being held often enough, and there may be a need for the club to increase the frequency of such events to better support student learning.

5.5 Subgoal E: Explore the sense of community and communication fostered by IITCPC

Question 15: How effectively does IITCPC communicate about its events and opportunities?

Null Hypothesis (H_0):

There is no significant difference between students rating IITCPC's communication as low(1-2) versus high(3-4) — responses are equally distributed.

Calculation:

| Group | O | E | $\frac{(O - E)^2}{E}$ |
|-------|----|----|-----------------------|
| Low | 21 | 16 | $(5^2)/16 = 1.5625$ |
| High | 11 | 16 | $(-5)^2/16 = 1.5625$ |
| Sum | | | 3.125 |

Degrees of Freedom: $df=2-1=1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841
Calculated chi-square = $3.125 < 3.841 \rightarrow p\text{-value} > 0.05$

Decision on H_0 :

Since $p > 0.05$, we fail to reject the null hypothesis.

Conclusion:

The chi-square test result indicates no statistically significant difference between students who rated IITCPC's communication as low and those who rated it as high. Although a larger number

of students perceive the communication as poor or merely adequate, the difference is not strong enough to be considered significant. This suggests that while communication may need improvement, the current perception is fairly spread out and not overwhelmingly negative. There is an opportunity here for IITCPC to improve its visibility and outreach to better inform students of events and opportunities.

Question 16: Have you formed study groups, teams, or discussion circles through IITCPC?

Null Hypothesis (H_0):

The proportion of students who have formed study groups, teams, or discussion circles through IITCPC is 50%, i.e. half the students formed some peer groups or circles for discussion on CP.

Calculation:

| Variable | Value |
|---------------------------------|--|
| Sample size (n) | 32 |
| Number of "Yes" (x) | 5 |
| Sample proportion (\hat{p}) | $5 / 32 = 0.156$ |
| Null proportion (p_0) | 0.5 |
| Standard error (SE) | $\sqrt{\frac{p_0(1-p_0)}{n}} = 0.0884$ |
| Test statistic (z) | $\frac{(\hat{p} - p_0)}{SE} = -3.83$ |

The calculated z-value is -3.83, corresponding to a p-value much less than 0.0001. Since the p-value is below the significance level of 0.05.

Decision on H_0 :

As $p < 0.05$, we reject the null hypothesis.

Conclusion:

The survey reveals that only 15.6% of respondents have formed study groups, teams, or discussion circles through IITCPC. This low proportion suggests that although IITCPC has succeeded in building awareness, it has been less effective in encouraging or facilitating collaborative learning and peer support networks. Enhancing opportunities for group formation and teamwork could help strengthen the competitive programming culture and improve student engagement within the club.

Question 17: Does IITCPC foster collaboration, competition, or both?**Null Hypothesis (H_0):**

The distribution of student responses among "competition," "collaboration," and "both" is uniform, meaning there is no preference for any particular aspect of IITCPC's culture.

Calculation:

| Category | O | $\frac{(O - E)^2}{E}$ |
|---------------|----|-----------------------|
| Competition | 17 | 3.75 |
| Collaboration | 3 | 5.51 |
| Both | 12 | 0.17 |
| Total | 32 | 9.43 |

Degrees of Freedom: $df=3-1=2$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 2 df ≈ 5.991

Calculated chi-square = 9.43 > 5.991 \rightarrow p-value < 0.05

Decision on H_0 :

Since $p < 0.05$, we fail to reject the null hypothesis.

Conclusion:

The results indicate that a majority of respondents (53.1%) perceive IITCPC as fostering competition, while a smaller portion (37.5%) believe it fosters both collaboration and competition equally. Only a few (9.4%) feel that the club primarily fosters collaboration. This suggests that IITCPC is largely seen as a competitive environment, but with notable recognition of collaborative aspects as well. These insights could guide the club in balancing competitive spirit with collaborative support to strengthen the overall culture.

Question 18: How satisfied are you with IITCPC's efforts to build an inclusive CP community?**Null Hypothesis (H_0):**

There is no significant difference in the distribution of student satisfaction levels; students are equally likely to report low satisfaction (ratings 1–2) or high satisfaction (ratings 3–5) with IITCPC's efforts to build an inclusive CP community.

Calculation:

| Group | O | E | $\frac{(O - E)^2}{E}$ |
|-------|----|----|-----------------------|
| Low | 8 | 16 | $(-8)^2/16=4$ |
| High | 24 | 16 | $(8)^2/16=4$ |
| Sum | | | 8 |

Degrees of Freedom: $df = 2 - 1 = 1$

Critical Value and P-value:

At $\alpha = 0.05$, the critical chi-square value with 1 df ≈ 3.841
Calculated chi-square = 8 > 3.841 \rightarrow p-value < 0.05

Decision on H_0 :

Since $p < 0.05$, we reject the null hypothesis.

Conclusion:

The results show a statistically significant difference between students expressing low satisfaction (ratings 1–2) and those with higher satisfaction (ratings 3–5) regarding IITCPC's inclusivity efforts. A majority (75%) fall into the higher satisfaction group, indicating moderate to positive feelings about inclusivity. However, the presence of a notable minority with low satisfaction suggests there is still room for improvement in fostering a more inclusive competitive programming community.

6. Final Thoughts

1. Awareness and Communication

- There is strong awareness of IITCPC among students, with the majority recognizing the club and its initiatives.
- Most students first learned about IITCPC through seniors and peers, emphasizing the effectiveness of word-of-mouth.
- However, this also highlights a gap in digital outreach and formal communication channels, which could be strengthened.

2. Participation and Engagement

- Student participation in IITCPC events varies significantly, with many attending only occasionally or rarely.
- A relatively small proportion of students engage frequently, suggesting the need for strategies to encourage more consistent involvement.
- This indicates that while IITCPC has broad reach, sustaining active participation remains a challenge.

3. Impact on Skills and Motivation

- Students reported mixed perceptions regarding improvements in competitive programming skills, motivation, and confidence.
- The responses suggest that IITCPC has a moderate impact in these areas, presenting opportunities to enhance its support systems and motivational efforts.

4. Learning Resources and Mentorship

- Feedback on the helpfulness of learning resources and adequacy of mentorship was varied.
- Many students felt that workshop frequency was low, indicating that more regular, hands-on sessions could better support skill development.

5. Community and Inclusivity

- While IITCPC fosters both collaboration and competition, few students reported forming study groups or consistent teams.
- Perceptions of inclusivity were moderate, suggesting that further initiatives to build a supportive and diverse community would be beneficial.

6. Value of the GQM Framework

- The Goal-Question-Metric (GQM) framework effectively connected the overall assessment goal with focused questions and measurable data.

- It enabled a structured analysis of both quantitative metrics and qualitative student perceptions across various areas of IITCPC's impact.

7. Overall Assessment

- IITCPC has successfully established a foundation for a competitive programming culture at IIT.
- However, there is substantial room for growth in increasing regular participation, enhancing mentorship for beginners, and fostering a more connected, inclusive community.
- Addressing these areas strategically can help IITCPC better support and inspire future students in their programming journeys.