CHAPTER 4
DATA ANALYSIS AND FINDINGS

4.1 AN OVERVIEW

The aim of the analysis is to organize, classify and summarize the collected data, so that they can be comprehended and interpreted to accomplish to research objectives. The profiles of the faculty members and students are presented in the first section of the chapter. The important contributing parameters of Institute–Industry Collaboration are described in the next section. Analysis of effectiveness of Institute–Industry Collaboration and testing of related hypotheses are also described. Methods used for identification of enhancing and limiting factors that play an important role on the effectiveness of Institute–Industry Collaboration and the results that emerged are highlighted. In the last section of this chapter, the generic model developed for Institute–Industry Collaboration is presented and the strategies identified for effective Institute–Industry Collaboration are also described.
### 4.2 PROFILE OF FACULTY MEMBERS AND STUDENTS

#### 4.2.1 Faculty Members’ Profile

Table 4.1 Profile of the Faculty Members

<table>
<thead>
<tr>
<th>Profile</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>171</td>
<td>58.20</td>
</tr>
<tr>
<td>Female</td>
<td>123</td>
<td>41.80</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Academic qualification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Master degree</td>
<td>258</td>
<td>87.80</td>
</tr>
<tr>
<td>Doctoral degree</td>
<td>36</td>
<td>12.20</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Teaching experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5 years</td>
<td>146</td>
<td>49.70</td>
</tr>
<tr>
<td>6–10 years</td>
<td>85</td>
<td>28.90</td>
</tr>
<tr>
<td>Above 10 years</td>
<td>63</td>
<td>21.40</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Industrial experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No experience</td>
<td>221</td>
<td>75.20</td>
</tr>
<tr>
<td>1–5 years</td>
<td>52</td>
<td>17.70</td>
</tr>
<tr>
<td>6–10 years</td>
<td>21</td>
<td>7.10</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Designation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professor</td>
<td>21</td>
<td>7.10</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>24</td>
<td>8.20</td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>249</td>
<td>84.70</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Programmes handled</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under Graduate</td>
<td>85</td>
<td>28.90</td>
</tr>
<tr>
<td>Post Graduate</td>
<td>191</td>
<td>61.60</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>28</td>
<td>9.50</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Department</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>52</td>
<td>17.70</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>55</td>
<td>18.70</td>
</tr>
<tr>
<td>Electronics &amp; Communication Engineering</td>
<td>51</td>
<td>17.30</td>
</tr>
<tr>
<td>Computer Science Engineering</td>
<td>74</td>
<td>25.20</td>
</tr>
<tr>
<td>Electrical &amp; Electronics Engineering</td>
<td>62</td>
<td>21.10</td>
</tr>
<tr>
<td>Total</td>
<td>294</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Faculty members’ profile includes gender, academic qualification, teaching experience, industrial experience, designation, programmes handled and academic department are shown in Table 4.1. 50% of faculty members had more than 5 years
teaching experience. 85% of faculty members were in the assistant professor cadre, and 25% of faculty members had industrial experience. There was a balanced distribution of faculty members among Civil Engineering, Mechanical Engineering, Electronics & Communication Engineering, Electrical & Electronics Engineering and Computer Science Engineering departments and the most of them handled post graduate courses followed by under graduate courses.

4.2.2 Students’ Profile

Table 4.2 Profile of the Students

<table>
<thead>
<tr>
<th>Profile</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>188</td>
<td>22.1</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>142</td>
<td>16.7</td>
</tr>
<tr>
<td>Electronics &amp; Communication Engineering</td>
<td>156</td>
<td>18.4</td>
</tr>
<tr>
<td>Computer Science Engineering</td>
<td>181</td>
<td>21.3</td>
</tr>
<tr>
<td>Electrical &amp; Electronics Engineering</td>
<td>183</td>
<td>21.5</td>
</tr>
<tr>
<td>Total</td>
<td>850</td>
<td>100.0</td>
</tr>
<tr>
<td>Years of study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II year</td>
<td>304</td>
<td>35.8</td>
</tr>
<tr>
<td>III year</td>
<td>284</td>
<td>33.4</td>
</tr>
<tr>
<td>IV year</td>
<td>262</td>
<td>30.8</td>
</tr>
<tr>
<td>Total</td>
<td>850</td>
<td>100.0</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>614</td>
<td>72.2</td>
</tr>
<tr>
<td>Female</td>
<td>236</td>
<td>27.8</td>
</tr>
<tr>
<td>Total</td>
<td>850</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Students’ profile includes department, years of study and gender are shown in Table 4.2. 72% of students were male. There was a balanced distribution of students among Civil Engineering, Mechanical Engineering, Electronics & Communication Engineering, Computer Science Engineering, Electrical & Electronics Engineering and across the three years of study.
4.3 IMPORTANT CONTRIBUTING PARAMETERS OF INSTITUTE–INDUSTRY COLLABORATION

The previous researchers have observed that various types of collaboration occurred between HEEI and industries and these collaborations are from primitive forms to advanced types. Based on the review of literature and discussions with academics and industrial personnel, 27 important contributing parameters have been identified for assessing the effectiveness of Institute–Industry Collaboration in HEEI. The grouping of the 27 parameters according to their intrinsic characteristics in six broad categories follows Inzelt (2004), Bhattacharya et al. (2007), De’Este et al. (2007), Sadagopan (2009) and they are listed in Table 4.3.

The details of the six broad categories of Institute–Industry Collaboration are described as below:

**Category 1 (C1)** – General Collaboration represents personal informal collaboration which helps to build up deeper levels of participation from industry.

**Category 2 (C2)** – Academic Level Collaboration involves a more specific collaboration of industry with higher level of participation than General Collaboration in HEEI.

**Category 3 (C3)** – Institutional Support Type Collaboration helps to overcome resource constraints of HEEI.

**Category 4 (C4)** – Service Type Collaboration helps the HEEI to generate financial resources by providing the services needed by industries.
**Category 5 (C5)** – Cooperative Type Collaboration involves formal research agreement under which original research is conducted in Institute–Industry Collaboration.

**Category 6 (C6)** – Student Level Collaboration helps the students to identify the industrial problems, to understand the best practices and needs of industries, and to generate funds for co-curricular activities.

**Table 4.3 Grouping of Parameters in Six Categories of Collaboration**

<table>
<thead>
<tr>
<th>Type of Institute–Industry Collaboration</th>
<th>Parameters Studied</th>
</tr>
</thead>
</table>
| **Category 1 (C1)** General Collaboration | C1.1. Participation of industrial personnel in workshops  
C1.2. Participation of industrial personnel in conferences  
C1.3. Participation of industrial personnel in seminars  
C1.4. Participation of industrial personnel in guest lectures  
C1.5. Participation of industrial personnel in committees |
| **Category 2 (C2)** Academic Level Collaboration | C2.1. Participation of industrial personnel in teaching process  
C2.2. Conduction of continuing education for industries  
C2.3. Involvement of industrial personnel in curriculum design  
C2.4. Joint publication of papers with the industries  
C2.5. Representation of industrial experts as external examiners for students |
| **Category 3 (C3)** Institutional Support Type Collaboration | C3.1. Participation of industries in research fellowships  
C3.2. Contribution of funds to attend workshops by the industries  
C3.3. Donation of instructional resource materials by the industries  
C3.4. Donation of laboratory equipments by the industries  
C3.5. Contribution for infrastructure development by the industries |
<table>
<thead>
<tr>
<th>Type of Institute–Industry Collaboration</th>
<th>Parameters Studied</th>
</tr>
</thead>
</table>
| **Category 4 (C4)** Service Type Collaboration | C4.1. Utilization of specialized laboratory equipments of the institute by the industries  
C4.2. Conduction of training programmes for the industries  
C4.3. Participation in consultancy assignment of the industries |
| **Category 5 (C5)** Cooperative Type Collaboration | C5.1. Participation in joint project with the industries  
C5.2. Participation in joint research with the industries  
C5.3. Participation in joint patent with the industries |
| **Category 6 (C6)** Student Level Collaboration | C6.1. Participation in industrial visits  
C6.2. Participation in industrial project works  
C6.3. Participation in summer trainings  
C6.4. Participation in internships  
C6.5. Sponsor of medals and rewards  
C6.6. Contribution of funds for co-curricular activities |

4.4 **EFFECTIVENESS OF INSTITUTE–INDUSTRY COLLABORATION IN HIGHER ENGINEERING EDUCATIONAL INSTITUTIONS**

In the present research study, the term effectiveness is the extent to which each type of collaboration has brought about the result intended, as assessed by the stakeholders. The term stakeholder refers to the persons of the organization who not only receive the services but also who obtain a benefit.

The approach followed to determine the effectiveness of the different types of collaboration in HEEI is described below.

The approach involved two parts.

**Part 1:** Determination of the effectiveness of the Institute–Industry Collaboration in HEEI as assessed by the faculty members

**Part 2:** Determination of the effectiveness of the Institute–Industry Collaboration in HEEI as assessed by the students
4.4.1 Effectiveness of Institute–Industry Collaboration as assessed by the Faculty Members

The Category 1 – Category 5 collaborations namely General Collaboration, Academic Level Collaboration, Institutional Support Type collaboration, Service Type Collaboration and Cooperative Type Collaboration were assessed by the faculty members. For this, each faculty member was asked to rate the effectiveness of each parameter on a 5 point scale ranging from 5 (Very High) to 1 (Very Low) and the same was collected using Instrument No. 3 (Appendix - IV). The mean and standard deviation (SD) of the scores assigned by all the faculty members were computed. The assessments of faculty members on the effectiveness of the parameters are presented in Table 4.4.

<table>
<thead>
<tr>
<th>Type of Collaboration</th>
<th>Parameters</th>
<th>Very Low (%)</th>
<th>Low (%)</th>
<th>Moderate (%)</th>
<th>High (%)</th>
<th>Very High (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1 (C1)</td>
<td>C1.1: Participation of industrial personnel in workshops</td>
<td>6.80</td>
<td>14.97</td>
<td>36.39</td>
<td>30.61</td>
<td>11.22</td>
<td>3.24</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>C1.2: Participation of industrial personnel in conferences</td>
<td>5.44</td>
<td>15.99</td>
<td>39.46</td>
<td>29.59</td>
<td>9.52</td>
<td>3.22</td>
<td>1.01</td>
</tr>
<tr>
<td></td>
<td>C1.3: Participation of industrial personnel in seminars</td>
<td>5.44</td>
<td>13.95</td>
<td>38.10</td>
<td>28.91</td>
<td>13.61</td>
<td>3.31</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>C1.4: Participation of industrial personnel in guest lectures</td>
<td>5.78</td>
<td>13.27</td>
<td>38.10</td>
<td>27.55</td>
<td>15.31</td>
<td>3.33</td>
<td>1.07</td>
</tr>
<tr>
<td></td>
<td>C1.5: Participation of industrial personnel in committees</td>
<td>7.82</td>
<td>22.79</td>
<td>37.07</td>
<td>24.49</td>
<td>7.82</td>
<td>3.03</td>
<td>1.05</td>
</tr>
<tr>
<td>Category 2 (C2)</td>
<td>C2.1: Participation of industrial personnel in teaching process</td>
<td>8.84</td>
<td>26.53</td>
<td>36.05</td>
<td>19.05</td>
<td>9.52</td>
<td>2.94</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>C2.2: Conduction of continuing education for industries</td>
<td>13.27</td>
<td>22.11</td>
<td>34.69</td>
<td>24.15</td>
<td>5.78</td>
<td>2.87</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>C2.3: Involvement of industrial personnel in curriculum design</td>
<td>7.14</td>
<td>21.43</td>
<td>35.03</td>
<td>23.47</td>
<td>12.93</td>
<td>3.14</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>C2.4: Joint publication of papers with the industries</td>
<td>23.13</td>
<td>32.31</td>
<td>26.87</td>
<td>10.20</td>
<td>7.48</td>
<td>2.47</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>C2.5: Representation of industrial experts as external examiners for students</td>
<td>21.43</td>
<td>32.99</td>
<td>27.55</td>
<td>10.88</td>
<td>7.14</td>
<td>2.49</td>
<td>1.15</td>
</tr>
<tr>
<td>Type of Collaboration</td>
<td>Parameters</td>
<td>Very Low (%)</td>
<td>Low (%)</td>
<td>Moderate (%)</td>
<td>High (%)</td>
<td>Very High (%)</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---------</td>
<td>--------------</td>
<td>----------</td>
<td>---------------</td>
<td>------</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>C3.2: Contribution of funds to attend workshops by the industries</td>
<td>15.99</td>
<td>21.77</td>
<td>28.91</td>
<td>25.51</td>
<td>7.82</td>
<td>2.87</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>C3.3: Donation of instructional resource materials by the industries</td>
<td>13.61</td>
<td>22.11</td>
<td>34.69</td>
<td>21.77</td>
<td>7.82</td>
<td>2.88</td>
<td>1.13</td>
</tr>
<tr>
<td></td>
<td>C3.4: Donation of laboratory equipments by the industries</td>
<td>17.35</td>
<td>26.19</td>
<td>31.63</td>
<td>15.31</td>
<td>9.52</td>
<td>2.73</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>C3.5: Contribution for infrastructure development by the industries</td>
<td>23.13</td>
<td>27.21</td>
<td>27.55</td>
<td>14.63</td>
<td>7.48</td>
<td>2.56</td>
<td>1.21</td>
</tr>
<tr>
<td>Category 4 (C4)</td>
<td>C4.1: Utilization of specialized laboratory equipments of the institute by the industries</td>
<td>11.90</td>
<td>16.67</td>
<td>32.31</td>
<td>30.27</td>
<td>8.84</td>
<td>3.07</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>C4.2: Conduction of training programmes for the industries</td>
<td>11.22</td>
<td>24.15</td>
<td>30.61</td>
<td>27.21</td>
<td>6.80</td>
<td>2.94</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>C4.3: Participation in consultancy assignment of the industries</td>
<td>15.31</td>
<td>27.21</td>
<td>33.33</td>
<td>18.37</td>
<td>5.78</td>
<td>2.72</td>
<td>1.11</td>
</tr>
<tr>
<td>Category 5 (C5)</td>
<td>C5.1: Participation in joint project with the industries</td>
<td>20.07</td>
<td>22.11</td>
<td>34.01</td>
<td>15.65</td>
<td>8.16</td>
<td>2.70</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>C5.2: Participation in joint research with the industries</td>
<td>20.07</td>
<td>28.91</td>
<td>28.91</td>
<td>14.97</td>
<td>7.14</td>
<td>2.60</td>
<td>1.17</td>
</tr>
<tr>
<td></td>
<td>C5.3: Participation in joint patent with the industries</td>
<td>30.95</td>
<td>29.59</td>
<td>22.79</td>
<td>11.90</td>
<td>4.76</td>
<td>2.30</td>
<td>1.16</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that

i) In all the five parameters under General Collaboration, the faculty members have assessed the effectiveness in the range of Moderate (Mean 3) to High (Mean 4) and the highest value of mean is for participation of industrial personnel in guest lectures.

ii) In all the five parameters under Academic Level Collaboration, the faculty members have assessed the effectiveness in the range of Low (Mean 2) to High (Mean 4) and the highest value of mean is for involvement of industrial personnel in curriculum design.
iii) In all the five parameters under Institutional Support Type Collaboration, the faculty members have assessed the effectiveness in the range of Low (Mean 2) to Moderate (Mean 3) and the highest value of mean is for donation of instructional resource materials by the industries.

iv) In all the three parameters under Service Type Collaboration, the faculty members have assessed the effectiveness in the range of Low (Mean 2) to High (Mean 4) and the highest value of mean is for utilization of specialized laboratory equipments of the institute by the industries.

v) In all the three parameters under Cooperative Type Collaboration, the faculty members have assessed the effectiveness in the range of Low (Mean 2) to Moderate (Mean 3) and the highest value of mean is for participation in joint project with the industries.

The mean of the scores assigned by all the faculty members for each parameter gives parameterwise effectiveness score. The total score for effectiveness of each category of collaboration was computed by adding the scores of all the parameters in the particular category of collaboration. The percentage of effectiveness of each category of collaboration was calculated by using the following formula:

\[
\text{Percentage of effectiveness} = \left( \frac{\text{Total score assigned}}{\text{Maximum possible score}} \right) \times 100
\]
Where,

1) The maximum possible score = (Number of parameters under each category of collaboration) x (Maximum mean score that can be obtained for a parameter)

2) Maximum mean score that can be obtained for a parameter is 5

The effectiveness of the five categories of Institute–Industry Collaboration as assessed by the faculty members are presented in Table 4.5.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type of Collaboration</th>
<th>Parameterwise Effectiveness</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C1.1 C1.2 C1.3 C1.4 C1.5</td>
<td>Total Score Assigned</td>
</tr>
<tr>
<td>1</td>
<td>Category 1 (C1)</td>
<td>General Collaboration</td>
<td>16.13 25 65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2.1 C2.2 C2.3 C2.4 C2.5</td>
<td>13.91 25 56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3.1 C3.2 C3.3 C3.4 C3.5</td>
<td>13.75 25 55</td>
</tr>
<tr>
<td>4</td>
<td>Category 4 (C4)</td>
<td>Service Type Collaboration</td>
<td>8.73 15 58</td>
</tr>
<tr>
<td>5</td>
<td>Category 5 (C5)</td>
<td>Cooperative Type Collaboration</td>
<td>7.60 15 51</td>
</tr>
</tbody>
</table>
The effectiveness of the five categories of Institute–Industry Collaboration as assessed by the faculty members is presented in Figure 4.1.

Figure 4.1 Effectiveness of the Five Categories of Institute–Industry Collaboration as assessed by the Faculty Members

The percentage of effectiveness of the five categories of Institute–Industry Collaboration in HEEI as assessed by the faculty members ranges from 51% to 65% and based on the assessments of faculty members, it can be concluded that Category 1 – General Collaboration (65%) is the most effective type of Institute–Industry Collaboration followed by Category 4 – Service Type Collaboration (58%), Category 2 – Academic Level Collaboration (56%), Category 3 – Institutional Support Type Collaboration (55%), and Category 5 – Cooperative Type Collaboration (51%).
4.4.2 Correlation Analysis of Effectiveness of Five Categories of Institute–Industry Collaboration as assessed by the Faculty Members

Correlation analysis of faculty members’ assessments on effectiveness of five categories of Institute–Industry Collaboration is presented in Table 4.6.

Table 4.6 Correlation Analysis on the Effectiveness of the Five Categories of Institute–Industry Collaboration as assessed by the Faculty Members

<table>
<thead>
<tr>
<th>TYPE OF COLLABORATION</th>
<th>Category 1 General Collaboration</th>
<th>Category 2 Academic Level Collaboration</th>
<th>Category 3 Institutional Support Type Collaboration</th>
<th>Category 4 Service Type Collaboration</th>
<th>Category 5 Cooperative Type Collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category 1 General Collaboration</td>
<td>1.000</td>
<td>0.627**</td>
<td>0.619**</td>
<td>0.591**</td>
<td>0.583**</td>
</tr>
<tr>
<td>Category 2 Academic Level Collaboration</td>
<td>0</td>
<td>1.000</td>
<td>0.762**</td>
<td>0.741**</td>
<td>0.753**</td>
</tr>
<tr>
<td>Category 3 Institutional Support Type Collaboration</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
<td>0.780**</td>
<td>0.765**</td>
</tr>
<tr>
<td>Category 4 Service Type Collaboration</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
<td>0.763**</td>
</tr>
<tr>
<td>Category 5 Cooperative Type Collaboration</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Note: ** denotes significance at the 0.01 level

From the above table, it can be inferred that

(i) The correlation coefficient between Category 1 and Category 2 is 0.627, which indicates 63% positive relationship and is significant at 1% level.

(ii) The correlation coefficient between Category 1 and Category 3 is 0.619, which indicates 62% positive relationship and is significant at 1% level.

(iii) The correlation coefficient between Category 1 and Category 4 is 0.591, which indicates 60% positive relationship and is significant at 1% level.
(iv) The correlation coefficient between Category 1 and Category 5 is 0.583, which indicates 59% positive relationship and is significant at 1% level.

(v) The correlation coefficient between Category 2 and Category 3 is 0.762, which indicates 76% positive relationship and is significant at 1% level.

(vi) The correlation coefficient between Category 2 and Category 4 is 0.741, which indicates 74% positive relationship and is significant at 1% level.

(vii) The correlation coefficient between Category 2 and Category 5 is 0.753, which indicates 75% positive relationship and is significant at 1% level.

(viii) The correlation coefficient between Category 3 and Category 4 is 0.78, which indicates 78% positive relationship and is significant at 1% level.

(ix) The correlation coefficient between Category 3 and Category 5 is 0.765, which indicates 77% positive relationship and is significant at 1% level.

(x) The correlation coefficient between Category 4 and Category 5 is 0.763, which indicates 77% positive relationship and is significant at 1% level.
The correlation analysis of effectiveness of the five categories of Institute–Industry Collaboration as assessed by the faculty members shows a positive correlation and hence it indicates that when effectiveness of anyone type of collaboration increases, the effectiveness of other types of collaboration also tend to increase.

The strength of a relationship between two collaborations is indicated by the absolute value of the correlation coefficient. The correlation coefficient between Category 3 and Category 4 has a high absolute value of 0.780. Therefore the relationship between Category 3 (Institutional Support Type Collaboration) and Category 4 (Service Type Collaboration) is stronger than the relationship between other categories of collaboration. The correlation coefficient between Category 1 and Category 5 has a low absolute value of 0.583. Therefore the relationship between Category 1 (General Collaboration) and Category 5 (Cooperative Type Collaboration) is weaker than the relationship between other categories of collaboration.

4.4.3 Effectiveness of Institute–Industry Collaboration as assessed by the Students

The sixth category of collaboration – Student Level Collaboration was assessed by the students. For this, each student was asked to rate the effectiveness of each parameter on a 5 point scale ranging from 5 (Very High) to 1 (Very Low) and the same was collected using Instrument No. 4 (Appendix - V). The mean and standard deviation (SD) of the scores assigned by all the students were computed. The assessments of students on all the parameters are presented in Table 4.7.
Table 4.7 Students’ Assessments of the Effectiveness of Institute–Industry Collaboration

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Very Low (%)</th>
<th>Low (%)</th>
<th>Medium (%)</th>
<th>High (%)</th>
<th>Very High (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6.1: Participation in industrial visits</td>
<td>18.20</td>
<td>16.20</td>
<td>30.50</td>
<td>19.60</td>
<td>15.40</td>
<td>2.98</td>
<td>1.30</td>
</tr>
<tr>
<td>C6.2: Participation in industrial project works</td>
<td>21.90</td>
<td>20.90</td>
<td>29.90</td>
<td>18.50</td>
<td>8.80</td>
<td>2.71</td>
<td>1.24</td>
</tr>
<tr>
<td>C6.3: Participation in summer trainings</td>
<td>21.10</td>
<td>18.70</td>
<td>30.20</td>
<td>18.50</td>
<td>11.50</td>
<td>2.81</td>
<td>1.28</td>
</tr>
<tr>
<td>C6.4: Participation in internships</td>
<td>23.60</td>
<td>20.60</td>
<td>29.90</td>
<td>18.00</td>
<td>7.90</td>
<td>2.66</td>
<td>1.23</td>
</tr>
<tr>
<td>C6.5: Sponsor of medals and rewards</td>
<td>28.10</td>
<td>25.30</td>
<td>28.80</td>
<td>10.80</td>
<td>6.90</td>
<td>2.43</td>
<td>1.20</td>
</tr>
<tr>
<td>C6.6: Contribution of funds for co-curricular activities</td>
<td>29.50</td>
<td>19.90</td>
<td>28.40</td>
<td>13.90</td>
<td>8.40</td>
<td>2.52</td>
<td>1.27</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that in all the six parameters under Student Level Collaboration, the students have assessed the effectiveness in the range of Low (Mean 2) – Moderate (Mean 3) and the highest value of mean is for participation in industrial visits and the lowest value of mean is for contribution of funds for co-curricular activities.

The mean of the scores assigned by all the students for the effectiveness of each parameter gives parameterwise effectiveness score. The total score for effectiveness of Category 6 was computed by adding the scores of all the parameters in the Student Level Collaboration. The percentage of effectiveness of Student Level Collaboration was calculated by using the following formula:

\[
\text{Percentage of effectiveness} = \left( \frac{\text{Total score assigned}}{\text{Maximum possible score}} \right) \times 100
\]
Where,

1) The maximum possible score = (Number of parameters under the Student Level Collaboration) x (Maximum mean score that can be obtained for a parameter)

2) Maximum mean score that can be obtained for a parameter is 5

The effectiveness of Student Level Collaboration as assessed by the students is presented in Table 4.8.

### Table 4.8 Data on the Effectiveness of Institute–Industry Collaboration as assessed by the Students

<table>
<thead>
<tr>
<th>Category 6 (C6): Student Level Collaboration</th>
<th>Total Score Assigned</th>
<th>Max. Possible Score</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6.1: Participation in industrial visits</td>
<td>2.98</td>
<td>16.11</td>
<td>30</td>
</tr>
<tr>
<td>C6.2: Participation in industrial project works</td>
<td>2.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.3: Participation in summer trainings</td>
<td>2.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.4: Participation in internships</td>
<td>2.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.5: Sponsor of medals and rewards</td>
<td>2.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.6: Contribution of funds for co-curricular activities</td>
<td>2.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The percentage of effectiveness of the sixth category of Institute–Industry Collaboration in HEEI as assessed by the students is 54% and based on the assessments of students, it can be concluded that in Category 6 the parameter C6.1 - participation in industrial visits is the most effective type of Institute–Industry Collaboration followed by C6.3 - participation in summer trainings, C6.2 - participation in industrial project works, C6.4 - participation in internships, C6.6 - contribution of funds for co-curricular activities and C6.5 - sponsor of medals and rewards.
4.5 TESTING OF HYPOTHESES

4.5.1 Testing of Hypotheses relating to the difference between the Assessments of Faculty Members with respect to the Effectiveness of Institute–Industry Collaboration

4.5.1.1 Faculty Members of Different Departments

Hypothesis I

Null Hypothesis: There is no significant difference between the assessments of faculty members of different departments with respect to the effectiveness of Institute–Industry Collaboration.

ANOVA for significant difference between the assessments of faculty members of different departments with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.9.

**Table 4.9 Summary of ANOVA for Faculty Members of Different Departments**

<table>
<thead>
<tr>
<th>Type of Institute–Industry Collaboration</th>
<th>Departments</th>
<th>Mean</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 - General Collaboration</td>
<td>Civil</td>
<td>16.25&lt;sup&gt;b&lt;/sup&gt; (4.36)</td>
<td>2.965</td>
<td>0.020*</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>14.42&lt;sup&gt;a&lt;/sup&gt; (5.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE</td>
<td>16.06&lt;sup&gt;b&lt;/sup&gt; (3.83)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>16.72&lt;sup&gt;b&lt;/sup&gt; (3.82)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEE</td>
<td>16.89&lt;sup&gt;b&lt;/sup&gt; (4.55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2 - Academic Level Collaboration</td>
<td>Civil</td>
<td>14.48&lt;sup&gt;ab&lt;/sup&gt; (4.22)</td>
<td>2.532</td>
<td>0.041*</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>12.98&lt;sup&gt;a&lt;/sup&gt; (4.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE</td>
<td>12.80&lt;sup&gt;b&lt;/sup&gt; (4.13)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>14.05&lt;sup&gt;ab&lt;/sup&gt; (3.81)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEE</td>
<td>14.97&lt;sup&gt;b&lt;/sup&gt; (4.97)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3 - Institutional Support Type Collaboration</td>
<td>Civil</td>
<td>13.88 (4.55)</td>
<td>2.258</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>12.40 (5.88)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE</td>
<td>13.27 (4.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>13.86 (5.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEE</td>
<td>15.13 (5.39)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4 - Service Type Collaboration</td>
<td>Civil</td>
<td>9.44 (2.87)</td>
<td>2.320</td>
<td>0.057</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>8.11 (3.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE</td>
<td>8.16 (2.49)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>8.72 (2.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEE</td>
<td>9.21 (3.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5 - Cooperative Type Collaboration</td>
<td>Civil</td>
<td>7.63 (3.23)</td>
<td>2.219</td>
<td>0.067</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>7.13 (3.39)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE</td>
<td>7.14 (2.95)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>7.36 (3.16)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEE</td>
<td>8.65 (3.57)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall effectiveness of Institute–Industry Collaboration</td>
<td>Civil</td>
<td>61.69&lt;sup&gt;ab&lt;/sup&gt; (16.44)</td>
<td>2.744</td>
<td>0.029*</td>
</tr>
<tr>
<td></td>
<td>Mechanical</td>
<td>55.04&lt;sup&gt;a&lt;/sup&gt; (20.29)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECE</td>
<td>57.43&lt;sup&gt;a&lt;/sup&gt; (14.73)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSE</td>
<td>60.72&lt;sup&gt;ab&lt;/sup&gt; (15.50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEE</td>
<td>64.84&lt;sup&gt;b&lt;/sup&gt; (19.49)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:  
1. * Denotes significance at 5% level  
2. Different alphabet between faculty members of different departments denotes significance at 5% level using Duncan Multiple Range test  
3. The value within bracket refers to standard deviation (SD)
From the above table, it can be inferred that

(i) Since P value is less than 0.05, the null hypothesis is rejected at 5% level of significance for General Collaboration and Academic Level Collaboration. Hence, it is concluded that there is significant difference in General Collaboration and Academic Level Collaboration in the assessments of faculty members of different departments with respect to the effectiveness of Institute–Industry Collaboration.

(ii) Since P value is greater than 0.05, the null hypothesis is accepted at 5% level of significance for Institutional Support Type Collaboration, Service Type Collaboration and Cooperative Type Collaboration. Hence, it is concluded that there is no significant difference in Institutional Support Type Collaboration, Service Type Collaboration, and Cooperative Type Collaboration in the assessments of faculty members of different departments with respect to the effectiveness of Institute–Industry Collaboration.

(iii) Based on Duncan Multiple Range test, General Collaboration of Civil, ECE, CSE and EEE departments are significantly higher (at 5% level) on Institute–Industry Collaboration than Mechanical department but there is no significant difference between Civil, ECE, CSE and EEE departments.
(iv) Based on Duncan Multiple Range test, Academic Level Collaboration of EEE is significantly higher (at 5% level) on Institute–Industry Collaboration than Mechanical Engineering and ECE but Civil Engineering and CSE are not significant with other departments.

4.5.1.2 Faculty Members with Different Designations

HYPOTHESIS II

Null Hypothesis: There is no significant difference between the assessments of faculty members with different designations with respect to the effectiveness of Institute–Industry Collaboration.

ANOVA for significant difference between assessments of faculty members with different designations with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.10.

<table>
<thead>
<tr>
<th>Type of Institute–Industry Collaboration</th>
<th>Designations</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Professor</td>
<td>Associate Professor</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>C1 – General Collaboration</td>
<td>Mean 15.29</td>
<td>15.88</td>
<td>16.22</td>
</tr>
<tr>
<td></td>
<td>(4.85)</td>
<td>(4.86)</td>
<td>(4.32)</td>
</tr>
<tr>
<td>C2 – Academic Level Collaboration</td>
<td>Mean 12.95</td>
<td>15.00</td>
<td>13.88</td>
</tr>
<tr>
<td></td>
<td>(3.65)</td>
<td>(5.01)</td>
<td>(4.46)</td>
</tr>
<tr>
<td>C3 – Institutional Support Type Collaboration</td>
<td>Mean 10.90</td>
<td>14.75</td>
<td>13.90</td>
</tr>
<tr>
<td></td>
<td>(4.27)</td>
<td>(6.09)</td>
<td>(5.01)</td>
</tr>
<tr>
<td>C4 – Service Type Collaboration</td>
<td>Mean 7.67</td>
<td>8.88</td>
<td>8.82</td>
</tr>
<tr>
<td></td>
<td>(2.82)</td>
<td>(3.39)</td>
<td>(2.89)</td>
</tr>
<tr>
<td>C5 – Cooperative Type Collaboration</td>
<td>Mean 5.90</td>
<td>8.42</td>
<td>7.66</td>
</tr>
<tr>
<td></td>
<td>(2.66)</td>
<td>(3.91)</td>
<td>(3.25)</td>
</tr>
<tr>
<td>Overall effectiveness of Institute–Industry Collaboration</td>
<td>Mean 52.71</td>
<td>62.92</td>
<td>60.48</td>
</tr>
<tr>
<td></td>
<td>(12.94)</td>
<td>(21.76)</td>
<td>(17.42)</td>
</tr>
</tbody>
</table>

Note: 1. * Denotes significance at 5% level
2. Different alphabet between faculty members of different designations denotes significance at 5% level using Duncan Multiple Range test
3. The value within bracket refers to standard deviation (SD)
From the above table, it can be inferred that

(i) Since P value is less than 0.05, the null hypothesis is rejected at 5% level of significance for Institutional Support Type Collaboration and Cooperative Type Collaboration. Hence, it is concluded that there is significant difference in Institutional Support Type Collaboration and Cooperative Type Collaboration in the assessments of faculty members of different designations with respect to the effectiveness of Institute–Industry Collaboration.

(ii) Since P value is greater than 0.05, the null hypothesis is accepted at 5% level of significance for General Collaboration, Academic Collaboration and Service Type Collaboration. Hence, it is concluded that there is no significant difference in General Collaboration, Academic Level Collaboration and Service Type Collaboration in the assessments of faculty members of different designations with respect to the effectiveness of Institute–Industry Collaboration.

(iii) Based on Duncan Multiple Range test, Institutional Support Type Collaboration of Associate Professor and Assistant Professor designations are significantly higher (at 5% level) on Institute–Industry Collaboration than Professor designation and there is no significant difference between Associate Professor and Assistant Professor designations.
Based on Duncan Multiple Range test, Cooperative Type Collaboration of Associate Professor and Assistant Professor designations are significantly higher (at 5% level) on Institute–Industry Collaboration than Professor designation.

4.5.1.3 Faculty Members with Different Years of Teaching Experience

HYPOTHESIS III

Null Hypothesis: There is no significant difference between the assessments of faculty members with different years of teaching experience with respect to the effectiveness of Institute–Industry Collaboration.

ANOVA for significant difference between the assessments of faculty members with different years of teaching experience with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.11.

<table>
<thead>
<tr>
<th>Type of Institute–Industry Collaboration</th>
<th>Teaching Experience in Years</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 - 5</td>
<td>6-10</td>
<td>Above 10</td>
</tr>
<tr>
<td>C1 – General Collaboration</td>
<td>Mean</td>
<td>15.78 (4.49)</td>
<td>16.14 (4.24)</td>
</tr>
<tr>
<td>C2 – Academic Level Collaboration</td>
<td>Mean</td>
<td>13.83 (4.70)</td>
<td>13.91 (4.18)</td>
</tr>
<tr>
<td>C3 – Institutional Support Type Collaboration</td>
<td>Mean</td>
<td>13.77 (4.95)</td>
<td>13.81 (5.28)</td>
</tr>
<tr>
<td>C4 – Service Type Collaboration</td>
<td>Mean</td>
<td>8.80 (2.95)</td>
<td>8.65 (2.98)</td>
</tr>
<tr>
<td>C5 – Cooperative Type Collaboration</td>
<td>Mean</td>
<td>7.69 (3.26)</td>
<td>7.59 (3.34)</td>
</tr>
<tr>
<td>Overall effectiveness of Institute–Industry Collaboration</td>
<td>Mean</td>
<td>59.87 (17.92)</td>
<td>60.09 (17.37)</td>
</tr>
</tbody>
</table>

Note: The value within brackets refers to standard deviation (SD)

From the above table, it can be inferred that since P value is greater than 0.05, the null hypothesis is accepted at 5% level of significance for General Collaboration, Academic Level Collaboration, Institutional Support Type
Collaboration, Service Type Collaboration and Cooperative Type Collaboration. Hence, it is concluded that there is no significant difference in General Collaboration, Academic Level Collaboration, Institutional Support Type Collaboration, Service Type Collaboration and Cooperative Type Collaboration in the assessments of faculty members of different years of teaching experience with respect to the effectiveness of Institute–Industry Collaboration.

4.5.1.4 Faculty Members handling Different Programmes

HYPOTHESIS IV

Null Hypothesis: There is no significant difference between the assessments of faculty members handling different programmes with respect to the effectiveness of Institute–Industry Collaboration.

ANOVA for significant difference between the assessments of faculty members handling different programmes with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.12.

Table 4.12 Summary of ANOVA for Faculty Members handling Different Programmes

<table>
<thead>
<tr>
<th>Types of Institute–Industry Collaboration</th>
<th>Programmes handled</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UG</td>
<td>PG</td>
<td>Ph.D.</td>
</tr>
<tr>
<td>C1 – General Collaboration</td>
<td>Mean</td>
<td>15.85&lt;sup&gt;ab&lt;/sup&gt; (4.47)</td>
<td>16.55&lt;sup&gt;b&lt;/sup&gt; (4.19)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.615</td>
<td>0.028*</td>
</tr>
<tr>
<td>C2 – Academic Level Collaboration</td>
<td>Mean</td>
<td>13.88 (5.00)</td>
<td>14.02 (4.24)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.397</td>
<td>0.673</td>
</tr>
<tr>
<td>C3 – Institutional Support Type Collaboration</td>
<td>Mean</td>
<td>13.59 (5.10)</td>
<td>14.07 (5.03)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.617</td>
<td>0.200</td>
</tr>
<tr>
<td>C4 – Service Type Collaboration</td>
<td>Mean</td>
<td>8.76 (3.02)</td>
<td>8.82 (2.87)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.724</td>
<td>0.485</td>
</tr>
<tr>
<td>C5 – Cooperative Type Collaboration</td>
<td>Mean</td>
<td>7.80 (3.50)</td>
<td>7.67 (3.17)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.659</td>
<td>0.192</td>
</tr>
<tr>
<td>Overall effectiveness of Institute–Industry Collaboration</td>
<td>Mean</td>
<td>59.88 (18.65)</td>
<td>61.13 (17.07)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.816</td>
<td>0.165</td>
</tr>
</tbody>
</table>

Note: 1. * Denotes significance at 5% level
2. Different alphabet between faculty members handling different programmes denotes significance at 5% level using Duncan Multiple Range test
3. The value within bracket refers to standard deviation (SD)
From the above table, it can be inferred that

(i) Since P value is less than 0.05, the null hypothesis is rejected at 5% level of significance for General Collaboration. Hence, it is concluded that there is significant difference in General Collaboration in the assessments of faculty members handling different programmes with respect to the effectiveness of Institute–Industry Collaboration.

(ii) Since P value is greater than 0.05, the null hypothesis is accepted at 5% level of significance. Hence, it is concluded that there is no significant difference in Academic Level Collaboration, Institutional Support Type Collaboration, Service Type Collaboration and Cooperative Type Collaboration in the assessments of faculty members handling different programmes with respect to the effectiveness of Institute–Industry Collaboration.

(iii) Based on Duncan Multiple Range test, General Collaboration of faculty members handling PG programme are significantly higher level (at 5% level) on Institute–Industry Collaboration than faculty members handling Ph.D. programme but faculty members handling UG programme are not significant with other groups.
4.5.2 Testing of Hypotheses relating to the difference between the Mean Ranks of Parameters assessed by the Faculty Members with respect to the Effectiveness of Institute–Industry Collaboration

4.5.2.1 Mean Ranks of Parameters in General Collaboration

HYPOTHESIS V

Null Hypothesis: There is no significant difference between the mean ranks of parameters in General Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

Friedman test for significant difference between the mean ranks of parameters in General Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.13.

Table 4.13 Friedman Test for Mean Ranks of Parameters in General Collaboration assessed by the Faculty Members

<table>
<thead>
<tr>
<th>Category I (C1): General Collaboration</th>
<th>Mean Ranks</th>
<th>Chi-square value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1.1: Participation of industrial personnel in workshops</td>
<td>3.03</td>
<td>45.598</td>
<td>0.001**</td>
</tr>
<tr>
<td>C1.2: Participation of industrial personnel in conferences</td>
<td>2.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1.3: Participation of industrial personnel in seminars</td>
<td>3.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1.4: Participation of industrial personnel in guest lectures</td>
<td>3.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1.5: Participation of industrial personnel in committees</td>
<td>2.62</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** Denotes significance at 1% level

From the above table, it can be inferred that in General Collaboration, since P value is less than 0.01, the null hypothesis is rejected at 1% level of significance. Hence, it is concluded that there is significant difference between mean ranks of parameters in General Collaboration with respect to the effectiveness of Institute–Industry Collaboration. Based on mean ranks, it is inferred that in General Collaboration, participation of industrial personnel in guest lectures (3.21) is the most effective type of Institute–Industry Collaboration followed by participation of industrial personnel in seminars (3.18), participation of industrial personnel in
workshops (3.03), participation of industrial personnel in conferences (2.97) and participation of industrial personnel in committees (2.62).

4.5.2.2 Mean Ranks of Parameters in Academic Level Collaboration

HYPOTHESIS VI

Null Hypothesis: There is no significant difference between the mean ranks of parameters in Academic Level Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

Friedman test for significant difference between the mean ranks of parameters in Academic Level Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration is listed in Table 4.14.

Table 4.14 Friedman Test for Mean Ranks of Parameters in Academic Level Collaboration assessed by the Faculty Members

<table>
<thead>
<tr>
<th>Category 2 (C2): Academic Level Collaboration</th>
<th>Mean Ranks</th>
<th>Chi-square value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2.1: Participation of industrial personnel in teaching process</td>
<td>3.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2.2: Conduction of continuing education for industries</td>
<td>3.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2.3: Involvement of industrial personnel in curriculum design</td>
<td>3.48</td>
<td>135.893</td>
<td>0.001**</td>
</tr>
<tr>
<td>C2.4: Joint publication of papers with the industries</td>
<td>2.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2.5: Representation of industrial experts as external examiners for students</td>
<td>2.55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** Denotes significance at 1% level

From the above table, it can be inferred that in Academic Level Collaboration, since P value is less than 0.01, the null hypothesis is rejected at 1% level of significance. Hence, it is concluded that there is significant difference between mean ranks of parameters in Academic Level Collaboration with respect to the effectiveness of Institute–Industry Collaboration. Based on mean ranks,
it is inferred that in Academic Level Collaboration, involvement of industrial personnel in curriculum design (3.48) is most effective parameter followed by participation of industrial personnel in teaching process (3.29), conduction of continuing education for industries (3.15), representation of industrial experts as external examiners for students (2.55) and joint publication of papers with the industries (2.52).

4.5.2.3 Mean Ranks of Parameters in Institutional Support Type Collaboration

**HYPOTHESIS VII**

*Null Hypothesis:* There is no significant difference between the mean ranks of parameters in Institutional Support Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

Friedman test for significant difference between the mean ranks of parameters in Institutional Support Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.15.

| Table 4.15  Friedman Test for Mean Ranks of Parameters in Institutional Support Type Collaboration assessed by the Faculty Members |
|---|---|---|---|
| Category 3 (C3): Institutional Support Type Collaboration | Parameters | Mean Ranks | Chi-square value | P value |
| C3.1: Participation of industries in research fellowships | 2.96 | | | |
| C3.2: Contribution of funds to attend workshops by the industries | 3.22 | | | |
| C3.3: Donation of instructional resource materials by the industries | 3.20 | 41.067 | 0.001** |
| C3.4: Donation of laboratory equipments by the industries | 2.96 | | | |
| C3.5: Contribution for infrastructure development by the industries | 2.67 | | | |

Note: ** Denotes significance at 1% level
From the above table, it can be inferred that in Institutional Support Type Collaboration, since P value is less than 0.01, the null hypothesis is rejected at 1% level of significance. Hence, it is concluded that there is significant difference between mean ranks of parameters in Institutional Support Type Collaboration with respect to the effectiveness of Institute–Industry Collaboration. Based on mean ranks, it is inferred that in Institutional Support Type Collaboration, contribution of funds to attend workshops by the industries (3.22) is most effective type parameter followed by donation of instructional resource materials by the industries (3.20), participation of industries in research fellowships (2.96), donation of laboratory equipments by the industries (2.96) and contribution for infrastructure development by the industries (2.67).

4.5.2.4 Mean Ranks of Parameters in Service Type Collaboration

HYPOTHESIS VIII

Null Hypothesis: There is no significant difference between the mean ranks of parameters in Service Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

Friedman test for significant difference between the mean ranks of parameters in Service Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.16.
Table 4.16 Friedman Test for Mean Ranks of Parameters in Service Type Collaboration assessed by the Faculty Members

<table>
<thead>
<tr>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4.1: Utilization of specialized laboratory equipments of the institute by the industries</td>
</tr>
<tr>
<td>C4.2: Conduction of training programmes for the industries</td>
</tr>
<tr>
<td>C4.3: Participation in consultancy assignment of the industries</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean Ranks</th>
<th>Chi-Square value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4.1</td>
<td>2.17</td>
<td>36.930</td>
<td>0.001**</td>
</tr>
<tr>
<td>C4.2</td>
<td>2.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4.3</td>
<td>1.81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** Denotes significance at 1% level

From the above table, it can be inferred that in Service Type Collaboration, since P value is less than 0.01, the null hypothesis is rejected at 1% level of significance. Hence, it is concluded that there is significant difference between mean ranks of parameters in Service Type Collaboration with respect to the effectiveness of Institute–Industry Collaboration. Based on mean ranks, it is inferred that in Service Type Collaboration, utilization of specialized laboratory equipments of the institute by the industries (2.17) is most effective parameter followed by conduction of training programmes for the industries (2.02) and participation in consultancy assignment of the industries (1.81).

4.5.2.5 Mean Ranks of Parameters in Cooperative Type Collaboration

HYPOTHESIS IX

Null Hypothesis: There is no significant difference between the mean ranks of parameters in Cooperative Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration.

Friedman test for significant difference between the mean ranks of parameters in Cooperative Type Collaboration assessed by the faculty members with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.17.
Table 4.17 Friedman Test for Mean Ranks of Parameters in Cooperative Type Collaboration assessed by the Faculty Members

<table>
<thead>
<tr>
<th>Category 5 (C5): Cooperative Type Collaboration</th>
<th>Parameters</th>
<th>Mean Ranks</th>
<th>Chi-square value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C5.1: Participation in joint project with the industries</td>
<td>2.18</td>
<td>77.382</td>
<td>0.001**</td>
<td></td>
</tr>
<tr>
<td>C5.2: Participation in joint research with the industries</td>
<td>2.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5.3: Participation in joint patent with the industries</td>
<td>1.75</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** Denotes significance at 1% level

From the above table, it can be inferred that in Cooperative Type Collaboration, since P value is less than 0.01, the null hypothesis is rejected at 1% level of significance. Hence, it is concluded that there is significant difference between mean ranks of parameters in Cooperative Type Collaboration with respect to the effectiveness of Institute–Industry Collaboration. Based on mean ranks, it is inferred that in Cooperative Type Collaboration, participation in joint project with the industries (2.18) is most effective parameter followed by participation in joint research with the industries (2.07) and participation in joint patent with the industries (1.75).

4.5.3 Testing of Hypotheses relating to the difference between the Assessments of Students with respect to the Effectiveness of Institute–Industry Collaboration

4.5.3.1 Students of Different Departments

HYPOTHESIS X

Null Hypothesis: There is no significant difference between the assessments of students of different departments with respect to the effectiveness of Institute–Industry collaboration.

ANOVA for significant difference between the assessments of students of different departments with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.18.
Table 4.18  Summary of ANOVA for Students of Different Departments

<table>
<thead>
<tr>
<th>Category 6 (C6): Student Level Collaboration</th>
<th>Mean</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Engineering</td>
<td>15.79</td>
<td>7.338</td>
<td>0.001**</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>14.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECE</td>
<td>15.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSE</td>
<td>16.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EEE</td>
<td>18.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1. * Denotes significance at 5% level
2. Different alphabet between students of different departments denotes significance at 5% level using Duncan Multiple Range test
3. The value within bracket refers to standard deviation (SD)

From the above table, it can be inferred that

(i) Since P value is less than 0.01, the null hypothesis is rejected at 1% level of significance for Student Level Collaboration. Hence, it is concluded that there is significant difference in Student Level Collaboration in the assessments of students of different departments with respect to the effectiveness of Institute–Industry Collaboration.

(ii) Based on Duncan Multiple Range test, Student Level Collaboration of EEE department is significantly higher (at 5% level) on Institute–Industry Collaboration than Mechanical and CSE but Civil and ECE departments are not significant with other departments.

4.5.3.2 Students in Different Years of Study

HYPOTHESIS XI

Null Hypothesis: There is no significant difference between the assessments of students in different years of study with respect to the effectiveness of Institute–Industry Collaboration.
ANOVA for significant difference between the assessments of students in different years of study with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.19.

Table 4.19 Summary of ANOVA for Students in Different Years of Study

<table>
<thead>
<tr>
<th>Category 6 (C6): Student Level Collaboration</th>
<th>Mean</th>
<th>F value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of study</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II year</td>
<td>15.57 a</td>
<td>(6.51)</td>
<td></td>
</tr>
<tr>
<td>III year</td>
<td>15.21 a</td>
<td>(6.44)</td>
<td>13.060</td>
</tr>
<tr>
<td>IV year</td>
<td>17.70 b</td>
<td>(5.24)</td>
<td>0.001**</td>
</tr>
</tbody>
</table>

Note: 1. * Denotes significance at 5% level
2. Different alphabet between students of different years of study denotes significance at 5% level using Duncan Multiple Range test
3. The value within bracket refers to standard deviation (SD)

From the above table, it can be inferred that

(i) Since the p value is less than 0.01, the null hypothesis is rejected at 1% level of significance for Student Level Collaboration. Hence, it is concluded that there is significant difference in Student Level Collaboration in the assessments of students in different years of study with respect to the effectiveness of Institute–Industry Collaboration.

(ii) Based on Duncan Multiple Range test, Student Level Collaboration of IV year students are significantly higher (at 5% level) on Institute–Industry Collaboration than II and III years of students, but there is no significant difference between II and III years of students.
4.5.4 Testing of Hypothesis relating to the difference between the Mean Ranks of Parameters assessed by the Students with respect to the Effectiveness of Institute–Industry Collaboration

4.5.4.1 Mean Ranks of Parameters in Student Level Collaboration

HYPOTHESIS XII

Null Hypothesis: There is no significant difference between the mean ranks of parameters in Student Level Collaboration assessed by the students with respect to the effectiveness of Institute–Industry Collaboration.

Friedman test for significant difference between the mean ranks of parameters in Student Level Collaboration assessed by the students with respect to the effectiveness of Institute–Industry Collaboration is presented in Table 4.20.

Table 4.20 Friedman Test for Mean Ranks of Parameters assessed by the Students

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean Ranks</th>
<th>Chi-square value</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6.1: Participation in industrial visits</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.2: Participation in industrial project works</td>
<td>3.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.3: Participation in summer trainings</td>
<td>3.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.4: Participation in internships</td>
<td>3.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.5: Sponsor of medals and rewards</td>
<td>3.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6.6: Contribution of funds for co-curricular activities</td>
<td>3.23</td>
<td>218.797</td>
<td>0.001**</td>
</tr>
</tbody>
</table>

Note: ** Denotes significance at 1% level

From the above table, it can be inferred that in Student Level Collaboration, since the P value is less than 0.01, the null hypothesis is rejected at 1% level of significance. Hence, it is concluded that there is significant difference between mean ranks of parameters in Student Level Collaboration with respect to the effectiveness of Institute–Industry Collaboration. Based on mean ranks, it is inferred that in Student Level Collaboration, participation in industrial visits (4.00) is the most effective parameter followed by participation in summer trainings (3.71),
participation in industrial project works (3.57), participation in internships (3.45), contribution of funds for co-curricular activities (3.23) and sponsor of medals and rewards (3.04).

4.6 ENHANCING AND LIMITING FACTORS OF THE EFFECTIVENESS OF INSTITUTE–INDUSTRY COLLABORATION

The previous researchers have observed that the effectiveness of the Institute–Industry Collaboration is closely related to the enhancing and limiting factors of Institute–Industry Collaboration and these factors are also important in the design of effective policy to build and support Institute–Industry Collaboration. In this context, based on the review of literature and discussions with academics and industrial personnel, ten factors have been identified that are assumed to enhance and limit the effectiveness of Institute–Industry Collaboration. These factors are listed below:

**Enhancing factors**

1) Better understanding of existing capabilities for the development of industrial sector
2) Generating new science & technology (S&T) capabilities
3) Maintaining quality standards in academic and research & development (R&D) activities
4) Generation of R&D resources
5) Exposure to students to problem identification and research required in industry
Limiting factors

1) Lack of mutual trust and appreciation
2) Lack of infrastructure facilities
3) Different work culture
4) Location of the industry
5) Non availability of dedicated manpower

4.7 IDENTIFICATION OF ENHANCING AND LIMITING FACTORS THAT PLAY AN IMPORTANT ROLE ON THE EFFECTIVENESS OF INSTITUTE–INDUSTRY COLLABORATION

For identification of enhancing and limiting factors that play an important role on the effectiveness of Institute–Industry Collaboration, information was collected from the following stakeholders using Instruments 1, 2 & 5 (Appendices - I, III & VI)

1. Academic administrators
2. Placement coordinators
3. Representatives of industries

Each respondent was asked to rate the enhancing factors and limiting factors that play an important role on the effectiveness of Institute–Industry Collaboration in their order of importance on a 5 point scale ranging from 5 (Most Important) to 1 (Least Important). The perceptions of all the three categories of respondents on enhancing factors with the computed mean scores are presented in Sections 4.7.1.1, 4.7.1.2 and 4.7.1.3 and the overall perception of the enhancing factors that play an important role on the effectiveness of Institute–Industry Collaboration is presented in Section 4.7.1.4. The perceptions of all the three
categories of respondents on limiting factors with the computed mean scores are presented in Sections 4.7.2.1, 4.7.2.2 and 4.7.2.3 and the overall perception of the limiting factors that play an important role on the effectiveness of Institute–Industry Collaboration is presented in Section 4.7.2.4. The enhancing and limiting factors on the effectiveness of Institute–Industry Collaboration in the order of importance are identified from the overall perception of the three categories of respondents.

4.7.1 Identification of Important Enhancing Factors

4.7.1.1 Perceptions of Academic Administrators on Enhancing Factors

Each academic administrator was asked to rate the enhancing factors in the order of importance, the mean and standard deviation of the scores assigned by all the academic administrators were computed. The perceptions of academic administrators on enhancing factors are presented in Table 4.21.

<table>
<thead>
<tr>
<th>Enhancing Factors</th>
<th>Least Important (%)</th>
<th>Somewhat Important (%)</th>
<th>Important (%)</th>
<th>Very Important (%)</th>
<th>Most Important (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better understanding of existing capabilities for the development of industrial sector</td>
<td>0</td>
<td>0</td>
<td>20.00</td>
<td>60.00</td>
<td>20.00</td>
<td>4.00</td>
<td>0.65</td>
</tr>
<tr>
<td>Generating new S&amp;T capabilities</td>
<td>0</td>
<td>0</td>
<td>20.00</td>
<td>53.33</td>
<td>26.67</td>
<td>4.07</td>
<td>0.70</td>
</tr>
<tr>
<td>Maintaining quality standards in academic and R&amp;D activities</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>40.00</td>
<td>60.00</td>
<td>4.60</td>
<td>0.51</td>
</tr>
<tr>
<td>Generation of R&amp;D resources</td>
<td>0</td>
<td>0</td>
<td>26.67</td>
<td>33.33</td>
<td>40.00</td>
<td>4.13</td>
<td>0.83</td>
</tr>
<tr>
<td>Exposure to students to problem identification and research required in industry</td>
<td>0</td>
<td>0</td>
<td>40.00</td>
<td>40.00</td>
<td>20.00</td>
<td>3.80</td>
<td>0.77</td>
</tr>
</tbody>
</table>
From the above table, it can be inferred that the academic administrators’ perceptions of importance on the five enhancing factors are in the range of Important (Mean 3) – Most Important (Mean 5) and the highest value of mean is for maintaining quality standards in academic and R&D activities and the lowest value of mean is for exposure to students to problem identification and research required in industry.

4.7.1.2 Perceptions of Placement Coordinators on Enhancing Factors

Each placement coordinator was asked to rate the enhancing factors in the order of importance, the mean and standard deviation of the scores assigned by all the placement coordinators were computed. The perceptions of placement coordinators on enhancing factors are presented in Table 4.22.

<table>
<thead>
<tr>
<th>Enhancing Factors</th>
<th>Least Important (%)</th>
<th>Somewhat Important (%)</th>
<th>Important (%)</th>
<th>Very Important (%)</th>
<th>Most Important (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better understanding of existing capabilities for the development of industrial sector</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
<td>40.00</td>
<td>60.00</td>
<td>4.60</td>
<td>0.51</td>
</tr>
<tr>
<td>Generating new S&amp;T capabilities</td>
<td>0</td>
<td>0</td>
<td>6.67</td>
<td>40.00</td>
<td>53.33</td>
<td>4.47</td>
<td>0.64</td>
</tr>
<tr>
<td>Maintaining quality standards in academic and R&amp;D activities</td>
<td>0</td>
<td>0</td>
<td>26.67</td>
<td>33.33</td>
<td>40.00</td>
<td>4.13</td>
<td>0.83</td>
</tr>
<tr>
<td>Generation of R&amp;D resources</td>
<td>0</td>
<td>0</td>
<td>26.67</td>
<td>20.00</td>
<td>53.33</td>
<td>4.27</td>
<td>0.88</td>
</tr>
<tr>
<td>Exposure to students to problem identification and research required in industry</td>
<td>0</td>
<td>0</td>
<td>20.00</td>
<td>6.67</td>
<td>73.33</td>
<td>4.53</td>
<td>0.83</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that the placement coordinators’ perceptions of importance on the five enhancing factors are in the range of Very
Important (Mean 4) – Most Important (Mean 5) and the highest value of mean is for better understanding of existing capabilities for the development of industrial sector and the lowest value of mean is for maintaining quality standards in academic and R&D activities.

### 4.7.1.3 Perceptions of Representatives of Industries on Enhancing Factors

Each representative of industry was asked to rate the enhancing factors and limiting factors in the order of importance, the mean and standard deviation of the scores assigned by all the representatives of collaborating industries were computed. The perceptions of representatives of industries on enhancing factors are presented in Table 4.23.

<table>
<thead>
<tr>
<th>Enhancing Factors</th>
<th>Least Important (%)</th>
<th>Somewhat Important (%)</th>
<th>Important (%)</th>
<th>Very Important (%)</th>
<th>Most Important (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better understanding of existing capabilities for the development of industrial sector</td>
<td>0</td>
<td>10.00</td>
<td>13.33</td>
<td>33.33</td>
<td>43.33</td>
<td><strong>4.10</strong></td>
<td>0.99</td>
</tr>
<tr>
<td>Generating new S&amp;T capabilities</td>
<td>0</td>
<td>10.00</td>
<td>10.00</td>
<td>40.00</td>
<td>40.00</td>
<td><strong>4.10</strong></td>
<td>0.96</td>
</tr>
<tr>
<td>Maintaining quality standards in academic and R&amp;D activities</td>
<td>0</td>
<td>0</td>
<td>6.67</td>
<td>56.67</td>
<td>36.67</td>
<td><strong>4.30</strong></td>
<td>0.60</td>
</tr>
<tr>
<td>Generation of R&amp;D resources</td>
<td>3.33</td>
<td>6.67</td>
<td>10.00</td>
<td>50.00</td>
<td>30.00</td>
<td><strong>3.97</strong></td>
<td>1.00</td>
</tr>
<tr>
<td>Exposure to students to problem identification and research required in industry</td>
<td>0</td>
<td>6.67</td>
<td>6.67</td>
<td>26.67</td>
<td>60.00</td>
<td><strong>4.40</strong></td>
<td>0.89</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that the representatives of industries’ perceptions of importance on the five enhancing factors are in the range
of Important (Mean 3) – Most Important (Mean 5) and the highest value of mean is for exposure to students to problem identification and research required in industry and the lowest value of mean is for maintaining quality standards in academic and R&D activities.

4.7.1.4 Overall Perceptions of the Three Categories of Respondents on Enhancing Factors

In order to identify the overall perceptions by the three categories of respondents 1) academic administrators 2) placement coordinators and 3) representatives of industries on enhancing factors that play an important role on the effectiveness of Institute–Industry Collaboration, the weighted mean score was calculated for each factor. The overall perceptions on enhancing factors on the effectiveness of Institute–Industry Collaboration are presented in Table 4.24.

| Table 4.24 Overall Perceptions on Enhancing Factors on the Effectiveness of Institute–Industry Collaboration by the Three Categories of Respondents |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Enhancing Factors               | Category of respondents | | | | | | |
|                                 | Academic Administrators | Placement Coordinators | Representatives of Industries | Group Total |
|                                 | Mean  SD | Mean  SD | Mean  SD | Mean  SD | Weighted Mean | SD |
| Better understanding of existing capabilities for the development of industrial sector | 4.00 0.65 | 4.60 0.51 | 4.10 0.99 | 4.21 0.84 |
| Generating new S&T capabilities | 4.07 0.70 | 4.47 0.64 | 4.10 0.96 | 4.19 0.83 |
| Maintaining quality standards in academic and R&D activities | 4.60 0.51 | 4.13 0.83 | 4.30 0.60 | 4.33 0.66 |
| Generation of R&D resources     | 4.13 0.83 | 4.27 0.88 | 3.97 1.00 | 4.10 0.93 |
| Exposure to students to problem identification and research required in industry | 3.80 0.77 | 4.53 0.83 | 4.40 0.89 | 4.26 0.88 |
The enhancing factors on the effectiveness of Institute–Industry Collaboration perceived by the three categories of respondents in the order of importance are presented in Figure 4.2.

**Figure 4.2 Overall Perceptions on Enhancing Factors on the Effectiveness of Institute–Industry Collaboration**

Based on the perceptions of the three categories of respondents on the five enhancing factors of the effectiveness of Institute–Industry Collaboration, it can be concluded that maintaining quality standards in academic and R&D activities (4.33) is rated as the most important enhancing factor followed by exposure to students to problem identification and research required in industry (4.26), better understanding of existing capabilities for the development of industrial sector (4.21), generating new S&T capabilities (4.19) and generation of R&D resources (4.10).
4.7.2 Identification of Important Limiting Factors

4.7.2.1 Perceptions of Academic Administrators on Limiting Factors

Each academic administrator was asked to rate the limiting factors in the order of importance, the mean and standard deviation of the scores assigned by all the academic administrators were computed. The perceptions of academic administrators on limiting factors are presented in Table 4.25.

<table>
<thead>
<tr>
<th>Limiting Factors</th>
<th>Least Important (%)</th>
<th>Somewhat Important (%)</th>
<th>Important (%)</th>
<th>Very Important (%)</th>
<th>Most Important (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of mutual trust and appreciation</td>
<td>13.33</td>
<td>13.33</td>
<td>13.33</td>
<td>33.33</td>
<td>26.67</td>
<td>3.47</td>
<td>1.41</td>
</tr>
<tr>
<td>Lack of infrastructure facilities</td>
<td>13.33</td>
<td>06.67</td>
<td>13.33</td>
<td>13.33</td>
<td>53.33</td>
<td>3.87</td>
<td>1.51</td>
</tr>
<tr>
<td>Different work culture</td>
<td>20.00</td>
<td>20.00</td>
<td>20.00</td>
<td>33.33</td>
<td>6.67</td>
<td>2.87</td>
<td>1.30</td>
</tr>
<tr>
<td>Location of the industry</td>
<td>26.67</td>
<td>26.67</td>
<td>26.67</td>
<td>20.00</td>
<td>0.00</td>
<td>2.40</td>
<td>1.12</td>
</tr>
<tr>
<td>Non availability of dedicated manpower</td>
<td>13.33</td>
<td>06.67</td>
<td>53.33</td>
<td>13.33</td>
<td>13.33</td>
<td>3.07</td>
<td>1.16</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that the academic administrators’ perception of importance on the five limiting factors are in the range of Somewhat Important (Mean 2) to Very Important (Mean 4) and the highest value of mean is for lack of infrastructure facilities and the lowest value of mean is for location of the industry.
4.7.2.2 Perceptions of Placement Coordinators on Limiting Factors

Each placement coordinator was asked to rate the limiting factors in the order of importance, the mean and standard deviation of the scores assigned by all the placement coordinators were computed. The perceptions of placement coordinators on limiting factors are presented in Table 4.26.

Table 4.26 Placement Coordinators’ Perceptions on Limiting Factors

<table>
<thead>
<tr>
<th>Limiting Factors</th>
<th>Least Important (%)</th>
<th>Somewhat Important (%)</th>
<th>Important (%)</th>
<th>Very Important (%)</th>
<th>Most Important (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of mutual trust and appreciation</td>
<td>0</td>
<td>0</td>
<td>13.33</td>
<td>20.00</td>
<td>66.67</td>
<td>4.53</td>
<td>0.74</td>
</tr>
<tr>
<td>Lack of infrastructure facilities</td>
<td>0</td>
<td>0</td>
<td>20.00</td>
<td>60.00</td>
<td>20.00</td>
<td>4.00</td>
<td>0.65</td>
</tr>
<tr>
<td>Different work culture</td>
<td>0</td>
<td>0</td>
<td>40.00</td>
<td>60.00</td>
<td>00.00</td>
<td>3.60</td>
<td>0.51</td>
</tr>
<tr>
<td>Location of the industry</td>
<td>0</td>
<td>13.33</td>
<td>26.67</td>
<td>33.33</td>
<td>26.67</td>
<td>3.73</td>
<td>1.03</td>
</tr>
<tr>
<td>Non availability of dedicated manpower</td>
<td>0</td>
<td>0</td>
<td>46.67</td>
<td>20.00</td>
<td>33.33</td>
<td>3.87</td>
<td>0.92</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that the placement coordinators’ perception of importance on the five limiting factors are in the range of Important (Mean 3) – Most Important (Mean 5) and the highest value of mean is for lack of mutual trust and appreciation and the lowest value of mean is for different work culture.
4.7.2.3 Perceptions of Representatives of Industries on Limiting Factors

Each representative of industries was asked to rate the limiting factors in the order of importance, the mean and standard deviation of the scores assigned by all the academic administrators were computed. The perceptions of representatives of industries on limiting factors are presented in Table 4.27.

<table>
<thead>
<tr>
<th>Limiting Factors</th>
<th>Least Important (%)</th>
<th>Somewhat Important (%)</th>
<th>Important (%)</th>
<th>Very Important (%)</th>
<th>Most Important (%)</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of mutual trust and appreciation</td>
<td>03.33</td>
<td>16.67</td>
<td>30.00</td>
<td>16.67</td>
<td>33.33</td>
<td>3.60</td>
<td>1.22</td>
</tr>
<tr>
<td>Lack of infrastructure facilities</td>
<td>03.33</td>
<td>03.33</td>
<td>20.00</td>
<td>56.67</td>
<td>16.67</td>
<td>3.80</td>
<td>0.89</td>
</tr>
<tr>
<td>Different work culture</td>
<td>10.00</td>
<td>06.67</td>
<td>33.33</td>
<td>20.00</td>
<td>30.00</td>
<td>3.53</td>
<td>1.28</td>
</tr>
<tr>
<td>Location of the industry</td>
<td>10.00</td>
<td>13.33</td>
<td>23.33</td>
<td>33.33</td>
<td>20.00</td>
<td>3.40</td>
<td>1.25</td>
</tr>
<tr>
<td>Non availability of dedicated manpower</td>
<td>10.00</td>
<td>00.00</td>
<td>16.67</td>
<td>33.33</td>
<td>40.00</td>
<td>3.93</td>
<td>1.23</td>
</tr>
</tbody>
</table>

From the above table, it can be inferred that the representatives of industries’ perception of importance on the five limiting factors is in the range of Important (Mean 3) – Very Important (Mean 4) and the highest value of mean is for non availability of dedicated manpower and the lowest value of mean is for location of the industry.
4.7.2.4 Overall Perceptions of the Three Categories of Respondents on Limiting Factors

In order to identify the overall perceptions by the three categories of respondents 1) academic administrators 2) placement coordinators and 3) representatives of industries on limiting factors that play an important role on the effectiveness of Institute–Industry Collaboration, the weighted mean score was calculated for each factor. The overall perceptions on limiting factors on the effectiveness of Institute–Industry Collaboration are presented in Table 4.28.

Table 4.28 Overall Perceptions on Limiting Factors on the Effectiveness of Institute–Industry Collaboration by the Three Categories of Respondents

<table>
<thead>
<tr>
<th>Limiting Factors</th>
<th>Category of respondents</th>
<th>Group Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Academic Administrators</td>
<td>Placement Coordinators</td>
</tr>
<tr>
<td>Lack of mutual trust and appreciation</td>
<td>3.47</td>
<td>1.41</td>
</tr>
<tr>
<td>Lack of infrastructure facilities</td>
<td>3.87</td>
<td>1.51</td>
</tr>
<tr>
<td>Different work culture</td>
<td>2.87</td>
<td>1.30</td>
</tr>
<tr>
<td>Location of the industry</td>
<td>2.40</td>
<td>1.12</td>
</tr>
<tr>
<td>Non availability of dedicated manpower</td>
<td>3.07</td>
<td>1.16</td>
</tr>
</tbody>
</table>

The limiting factors on the effectiveness of Institute–Industry Collaboration perceived by the three categories of respondents in the order of importance are presented in Figure 4.3.
Figure 4.3 Overall Perceptions on Limiting Factors on the Effectiveness of Institute–Industry Collaboration

Based on the perceptions of the three categories of respondents on the five limiting factors of effectiveness of Institute–Industry Collaboration, it can be concluded that lack of infrastructure facilities (3.87) is rated as the most important limiting factor followed by lack of mutual trust and appreciation (3.82), non availability of dedicated manpower (3.66), different work culture (3.36) and location of the industry (3.21).
4.8 SUGGESTED MODEL AND STRATEGIES FOR EFFECTIVE INSTITUTE–INDUSTRY COLLABORATION

A model is nothing but a planned flow of activities (Salivahanan & Kamaraj, 2011) in sequence. Institute–Industry Collaboration is also a planned activity for the benefit of institute and industry. The suggested model and strategies will be very useful to other HEEI for effective implementation of Institute–Industry Collaboration.

4.8.1 Suggested Model for Effective Institute–Industry Collaboration

By referring the various Institute–Industry Collaboration models presented in the literature and by studying the suggestions given by the stakeholders of HEEI to improve Institute–Industry Collaboration, it was concluded that the institutions need a separate unit to coordinate and facilitate the various activities of Institute–Industry Collaboration. Keeping this in mind, a generic model for Institute–Industry Collaboration applicable for HEEI has been developed by the researcher. The validation of the model was done by a panel of experts. The panel consisted of 11 persons as listed below:

1. Vice Chancellor of a deemed university (n=1)

2. Directors or Principals of engineering institutions (n=2) under deemed universities

3. Dean, Placement or Placement Officers of engineering institutions (n=2) under deemed universities
4. Heads of the departments of engineering institutions (n=2) under deemed universities

5. Representatives of industries (n=4)

Based on the feedback received from the panel members, the model was fine-tuned and finalised. The validated model is presented in Figure 4.4.
Figure 4.4  Suggested Model for Effective Institute–Industry Collaboration
The component of the model and the various linkages between them are described below:

As indicated in the model, each HEEI should have (i) a separate Institute–Industry Collaboration unit. This unit will be a single point of contact for identifying the technical problems faced by industry and direct those to the concerned department faculties (ii) a two-tier advisory board structure – one at the apex level and the other at the sectoral level. These are called as

a. University Advisory Board (UAB)
b. Programme Advisory Board (PAB)

a) University Advisory Board

The UAB covers the entire institution. The UAB may be constituted with 9–15 members from public sector, private sector, academia and the Dean of Institute–Industry Collaboration unit. The Vice Chancellor of the institution will be the chair person. The main functions of UAB are listed below:

i) To advise the university on matters relating to the education imparted in the university.

ii) To discuss and deliberate on:
   - Building quality human capital
   - Excellence in education – technical & managerial.

iii) To suggest broad guiding principles which will enable the institution to become a world-class university.

iv) To advise the types of location / problem specific research works to be taken up in the university.
v) To advise the university on the nature of collaboration, it should have with industries, users organizations for carrying out its extension, education and research programmes.

vi) To help the university be globally competitive, develop global practices and benchmarks for both performance and rewards.

vii) To advise on the emerging trends in the Indian and global economies, with emphasis on sectoral shift, preparedness, competency and values and social commitment.

viii) To suggest measures:

• to facilitate and empower faculty members and students through industry engagements

• to develop learnability in student engagement

• to develop appropriate competency through interventions to match industrial / corporate requirements

• to suggest changes in curriculum based on emerging industry trend

• to attract faculty of high quality - globally

• faculty engagement interventions

• to facilitate excellence through corporate and institutional tie-ups.

ix) To advise on any other matters to be entrusted by the board of management of the university.
b) **Programme Advisory Board**

The PAB is discipline specific. For example, if an institution has four disciplines of study, it has to constitute four PABs. Each PAB may consist of 5–7 members of whom 3–4 are from industries. The PAB should consist of members from public sector, private sector and the dean of Institute–Industry Collaboration unit. The head of the department can be the member - convenor of the concerned PAB. One of the members of UAB may chair a PAB. This will provide a link between UAB and PABs for a two way consultation. The main functions of PABs are

1) to examine the educational and research infrastructures required

2) to identify all possible Institute–Industry Collaboration within a discipline

3) to identify new programmes and courses, and

4) to guide the development of updated and latest syllabi and curricula.

UAB and PABs being advisory bodies, the recommendations will be examined by the respective committees / boards of the university and they will provide half yearly feedback to PAB and UAB. The UAB and PAB may meet two times in a year with a gap of six months.

**Working committee**

The working committee of each university can consist of 5–6 members. Its composition includes Vice Chancellor, Dean of Institute–Industry Collaboration unit, key functionaries of the universities and heads of departments. Dean of Institute–Industry Collaboration unit will be the convenor and the Vice Chancellor will be the chair person. The main functions of the working committee include:
i) Making policy decisions

ii) Framing guidelines for the various activities of Institute–Industry Collaboration

iii) Allocation of resources needed for various activities of Institute–Industry Collaboration

iv) Reviewing and monitoring the progress made in the Institute–Industry Collaboration

**Institute–Industry Collaboration unit**

Institute–Industry Collaboration is a complex process and requires dedicated efforts to establish a system. The Institute–Industry Collaboration unit should be a distinctly identifiable organisational entity, which will be functionally independent of the main institution but organically linked to its structure. The main functions of Institute–Industry Collaboration unit are listed below:

a) It should be capable of mobilising the talents within the system individually, departmentally between disciplines

b) It should be capable of putting together effective co-operative networks of talents and institutions from within and outside

c) It should help in identifying the degree of complementarities among the departments and sponsors

d) It should adopt the role of a trustworthy facilitator with friendly disposition, flexible approach with focussed goals.

The Institute–Industry Collaboration unit should be headed by a senior person at the level of dean and should have good exposure to the needs of institutions and industry.
The Dean should be supported by two officers

1) Officer - Technology Services

2) Officer - Operation

The Officer - Technology Services should be responsible for liaison, coordination, marketing and promotional activities and publication of technical literature.

The Officer - Operations should be responsible for support services, maintenance of accounts, purchases and recruitment activities.

**Industry**

The HEEI may interact and establish collaboration with the following:

i) Private industries - single industry, consortia of industries, small & medium enterprises (SMEs) and multinational companies (MNCs)

ii) Public sectors

iii) Industrial bodies

iv) Government agencies

**Private sectors**

A higher engineering educational institution can establish collaboration with private sector companies in various technical fields. Private sector companies are run by individuals or groups, usually as a means of enterprise for profit, and are not controlled by the government.

**Public sector**

A higher engineering educational institution can establish collaboration with the public enterprises in various technical fields. A public enterprise is an organisation that is owned by public authorities such as central, state and local
authorities to an extent of 50% or more. It is established for the achievement of a defined set of public purposes, which may be multidimensional.

**Industrial bodies**

A higher engineering educational institution can establish collaboration with the industrial bodies such as CII, NASSCOM, etc.

**Government agencies**

A higher engineering educational institution can establish collaboration with departments and agencies of state and central government like public works, transport, pollution control boards etc.

**4.8.2 Strategies Suggested for Effective Institute–Industry Collaboration**

Johnson and Scholes (2002) defined strategy as follows: "Strategy is the direction and scope of an organization over the long-term, which achieves advantage for the organization through its configuration of resources within a challenging environment, to meet the needs of markets and to fulfill stakeholder expectations". In a nutshell, strategy is a method or plan chosen to bring about a desired future, such as achievement of a goal or solution to a problem.

The strategies for effective Institute–Industry Collaboration were identified by analyzing the information collected from the five categories of respondents (academic administrators, placement coordinators, faculty members, students and representatives of industries) and these strategies for HEEI are briefly described as follows:
1) **Inclusion of Institute–Industry Collaboration as a thrust area in the strategic plan of the HEEI**

- Institute–Industry Collaboration should be included as a thrust area in the strategic plan of the HEEI to develop goals, objectives including targets, work plan and action plan and to ensure allocation of adequate resources for Institute–Industry Collaboration activities.

- The working committee should periodically review and monitor the progress made in Institute–Industry Collaboration and should take appropriate policy decisions.

2) **Effective implementation of Institute–Industry Collaboration in HEEI**

- The 27 identified parameters of Industry–Institute Collaboration should be grouped under three categories depending on the duration required for implementation viz. Immediate (0–1 year), Short-term (1–3 years) and Long-term (3–5 years) for a sustainable and effective collaboration.

3) **Involving the departments of HEEI in the Institute–Industry Collaboration**

- All the departments in the institutions should have a senior faculty member to interact and coordinate with Institute–Industry Collaboration unit.

- All the departments should identify core teams having strength and interest in teaching and research / consultancy.

- All the departments should prepare information / fact sheets about the technical expertise of faculty members, equipments available, training,
consulting, testing, etc. conducted in the recent years in a standard format

- All the departments should prepare the calendar of needs such as adjunct faculty, visiting professor, etc. well before the start of semester
- The faculty members should be encouraged to engage with the industries and such activities can provide the individual faculty member with experience and knowledge valuable to teaching and research and also help students gain richer educational opportunities and experiences
- The PABs should advise and guide the departments in Institute–Industry Collaboration.

4) **Strengthening alumni association**

- The networking with the alumni should be strengthened to utilize the services of the alumni who are employed in industries to improve Institute–Industry Collaboration activities.

5) **Assessment and analysis of needs of industries**

- The assessment and analysis of needs of industries should be done to identify a range of need-based services, programmes and products that can be offered to industries.

6) **Nurturing industry focus culture**

- A culture should be developed to offer flexible curriculum, time and modes of delivery of trainings and programmes tailored to needs of the industries.
7) **Establishment of a system of reward and recognition for high performers**

- Rewards and incentives should be provided for high performing faculty members for the additional work done by them for achieving excellent results in the Institute–Industry Collaboration.

8) **Creation of a separate Institute–Industry Collaboration unit**

- A separate Institute–Industry Collaboration unit should be formed and a full time person should be appointed as the dean of the unit to act as a single point of contact for implementing various activities of collaboration.

- This will ensure that the dean will have adequate time and energy for implementing various activities of collaboration. The Dean should be a (a) team worker (b) facilitator and have (c) good understanding of the strengths of the departments and exposure to needs of the institution and industry.

- The Dean should also be trained periodically to develop his / her competencies to enable him / her to function effectively.

9) **Identification and training of appropriate backup person for dean**

- This will ensure sustainability of Institute–Industry Collaboration activities in the event of the incumbent Dean leaving the service or proceeding on long leave.
As a part of strategy, a methodology is suggested for effective implementation of Institute–Industry Collaboration activities in HEEI and the same is presented in Figure 4.5.

![Diagram](image)

**Figure 4.5 Methodology for Effective Implementation of Institute–Industry Collaboration**

The attempt in this chapter has been to get an analytical perspective of the effectiveness of collaboration between HEEI and industries. Based on the insight of this perspective, a model as well as strategies for effective Institute–Industry Collaboration has been developed. The next chapter presents a summary of the study, findings, conclusions and recommendations.