Analysis of the Efficiency of Teaching Methods: Using the Variance-Based Method as an Example

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ABSTRACT

This study was conducted with 110 students enrolled on a statistics course. The students completed a questionnaire before the end of the semester, evaluating the efficacy of the professor’s teaching methods. The students’ perceptions of the importance and performance of the professor’s teaching methods were calculated indirectly using the variance-based method of importance-performance analysis (IPA). The results scored six questions into Quadrant A, which means that these elements of the teacher’s methods provided low levels of satisfaction, but were given a high level of importance. Two questions are scored into Quadrant B, which indicated that they provided high levels of satisfaction and importance, and should be maintained. One question was scored into Quadrant C, which represented low levels of both satisfaction and importance, and should be improved in the future. Six questions were scored into Quadrant D, which denoted over-performance by the teacher, where the level of satisfaction is high but the level of importance is considered low. Finally, we recommend that teachers prioritize improving the less satisfactory elements of their teaching methods and use the results of this study to modify their lesson content and teaching strategies.

Keywords: efficiency of teaching, importance-performance analysis (IPA)

INTRODUCTION

Following changes to the social environment and value identification, the educational goals and teaching methods of colleges and other learning institutions should be adjusted accordingly. Using effective course design to cultivate students’ cultural literacy, independent cognition, scientific knowledge, and macro-perspective is also becoming increasingly important. College education is essentially an interaction and exchange between teachers and students. However, compared with the teaching methods employed by the teacher, students’ learning habits are significantly more important. Throughout the learning process, students’ ability to think, learn, and interpret the teacher’s actions determines whether they can learn the material. Therefore, throughout the learning process, if students do not possess a willingness to learn or lack fundamental skills, the teacher’s efforts will be futile. Student-teacher interaction, mutual feedback, and mutual evaluation are required to realize the complete benefits of teaching.

The goal of statistics education is cultivating the ability to solve everyday problems; thus, statistics courses should emphasize the connection between the problem and the data, as well as its impact on the statistical results. The fundamental concepts and methods of statistics education include mathematics. In addition to understanding statistics and being capable of reading statistical charts, guiding students to consider whether the chart accurately represents the distribution of data and the purposes of the solution is
essential. The goals of a statistics teacher should be to ensure “students acquire or possess a fundamental understanding of statistical concepts, are capable of employing these concepts to evaluate numerical data to solve statistical problems, and can explain the data and communicate using the language of statistics.” Currently, countries throughout the world, including Taiwan, have begun emphasizing statistics by reviving the provision of statistics courses. However, because of the long-term neglect of statistics by academic institutions and a decline in students’ mathematical capabilities, teachers feel unable to teach these courses and students lack the enthusiasm and motivation to study this subject. Garfield and Ahlgren (1988) stated that the problems regarding the efficacy of teaching statistics are based on (1) the role of statistics in courses; (2) the connection between the researcher and educator; (3) the preparation of statistics teachers; and (4) the learning evaluation methods. Shaughnessy (1992) contended that the obstacles to improving statistics education were (1) an inability to include statistics in the mainstream mathematics curriculum; (2) teachers’ lack of statistical background and understanding; and (3) the beliefs of students and teachers regarding statistics. Either teachers lack the experience and appropriate background to teach statistics, or they have a limited understanding of the purposes of teaching statistics, causing statistics education to stagnate.

Researchers have found that after entering college and selecting a statistics course, a considerable number of students develop a fear of the subject. Faced with the task of handling a string of numbers and confusing words, students appear to not recognize the value of learning statistics. This causes them to lose interest in the subject, and possibly confidence in their abilities, leading to a sense of helplessness. After losing their interest in learning statistics, students often tend to fear statistics. When faced with an examination, their strategy for managing similar questions is typically memorization. Their goal is only to achieve a high score. However, once the questions begin to vary, the students find themselves unable to employ the concepts they have studied to develop a solution. Thus, not only do the students lose their interest in learning, they may even lose their confidence, leading to a sense of helplessness. This situation causes statistics teachers substantial distress. The teachers hope that by adjusting their teaching methods, students interest in learning mathematics will increase. Because importance-performance analysis (IPA) is rapid, easy to use, and provides useful information directly, it can be adjusted to various subjects and course content and used to predict the qualities of various students. IPA can also be used by teachers to develop more effective teaching strategies because the students are the direct recipients of the teacher’s teaching. IPA is a technique that involves performing a relative position comparison of specified assessment categories using “importance” (the level of importance perceived by the test participant) and “performance” (the level of satisfaction perceived by the test participant) (Sampson & Showalter, 1999). This method originated in 1977, when Martilla and James (1977) proposed the original structure for IPA, which they employed to analyze the performance of the automotive industry, displaying importance and performance as a two-dimensional matrix. IPA can also be used to analyze customer satisfaction of a certain product or service attitude (Hawes & Rao, 1985). Because IPA is suitable for a broad range of applications, it is widely employed in the automobile, real estate, education, and medical industries (Martilla & James, 1977; Cunningham & Gaeth, 1989; Dolinsky, 1991; Shieh & Wu, 2009).

Regarding the analysis of specific behaviors or the importance of theories, the following methods are typically employed: (1) the variance-based method; (2) fuzzy linguistics; (3) the entropy method; (4) analytic hierarchy process (AHP); and (5) sensitivity analysis. For this study, we employed the variance-based method. Generally, performance can be directly inferred from the results of the questionnaire. The four quadrants of IPA each have different meanings, as shown in Fig. 1.
A. Concentrate Here: The test participants perceive the teaching element to be of high importance but low satisfaction. In other words, the students consider it to be extremely important, but the teacher underperforms for this element. Consequently, the students possess lower satisfaction with the teaching methods. Therefore, the teacher must exert significant effort to achieve the greatest effects of his or her teaching.

B. Keep Up the Good Work: The test participants perceive the teaching element to be of high importance and satisfaction. Classification into this quadrant means the teacher has performed well, and should continue with his or her methods.

C. Low Priority: The test participants perceive the teaching element to be of low importance and satisfaction. Elements scored into this quadrant are of low priority, and students do not expect a high level of satisfaction, nor do they view it with much importance. Teachers can give lower priority to these elements, improving them later.

D. Possible Overkill: The test participants perceive the teaching element to be of low importance but high satisfaction. Elements in this quadrant are overperformed; thus, they do not required further resource investments.

![Figure 2: Importance-Performance Analysis](image)

Normally, certain elements of teaching are given importance or consideration value because they receive mixed ratings. Greater deviation in ratings means a higher value of variance; thus, the weighted variance is considered the cornerstone of the concept of importance.

Assuming $x_k$ is the aspect number $k$, the weighted variance $w_k$ is derived using the following formula:

$$w_k = (Var(x_k) - m) / M$$

**Formula (1)**

where $Var(x_k) = \frac{1}{n_k} \sum_{j=1}^{n_k} (R_j(x_k) - \overline{R}_k)^2 / n_k - 1$. The difference between $m$ and $M$ represents the smallest and largest value of variance for all mathematical properties; $R_j(x_k)$ represents the rating of teaching element $k$ provided by student number $j$; $n_k$ is the number of students that rated the teaching aspect $x_k$, and $\overline{R}_k$ is the average rating of aspect $x_k$ (Herlocker, Konstan, Brochers, & Riedl,
1999). Practically, when the overall rating of a teaching aspect is unknown, the formula previously presented for weighted variance \( W_k = \frac{(Var(x_k) - m)}{M} \) can be used to derive the level of importance for each teaching element.

Using IPA, this study surveys students’ level of satisfaction of specific elements of the teacher’s teaching methods. Communicating what the students think of these elements to the teachers provides them with a reference for reforming their teaching methods.

**DATA COLLECTION AND SCALE**

Each case examined in this study uses college seniors enrolled on a statistics course at a specific institute of technology as the test participants. The sample comprised three classes containing 110 students, who were all taught by the same professor. Before the end of the semester, students were invited to participate in a study regarding the efficiency of the teaching methods employed by their statistics professor. The questionnaire used in this survey was referenced from the scale proposed by Chen, Chen, and Tseng (2008). The scale contains 15 questions and its reliability is based on the Cronbach’s \( \alpha \) coefficient, which is used to assess the internal consistency. The calculations yielded a reliability of \( \alpha = .914 \). According to the perspective of Nunally (1978), research tools with reliability above 0.7 are considered trustworthy. This indicates that the questionnaire is highly reliable. Additionally, the effectiveness of the questionnaire is assessed by experts, whose comments will be referenced for adjustment and improvement.

**ANALYSIS OF RESEARCH RESULTS**

Using the questionnaire and Formula (1) for analysis, the performance level of each individual teaching method, as well as the level of importance determined using the variance-based method, are shown in Table 1.

<table>
<thead>
<tr>
<th>Question no.</th>
<th>Teaching Elements</th>
<th>Importance</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The teacher’s professional knowledge of the subject and the robustness of the course content</td>
<td>0.000</td>
<td>4.364</td>
</tr>
<tr>
<td>2</td>
<td>The teacher’s level of preparation before class</td>
<td>0.001</td>
<td>4.400</td>
</tr>
<tr>
<td>3</td>
<td>The teacher’s adjustment of his or her teaching style according to the performance of students during the course</td>
<td>0.157</td>
<td>3.982</td>
</tr>
<tr>
<td>4</td>
<td>The teacher organizes and plans educational activities</td>
<td>0.207</td>
<td>4.100</td>
</tr>
<tr>
<td>5</td>
<td>The teacher uses metaphors, examples, and real-life cases to stimulate the cognition and interest of students</td>
<td>0.023</td>
<td>4.355</td>
</tr>
<tr>
<td>6</td>
<td>The teacher can select and organize key points during the class</td>
<td>0.177</td>
<td>4.127</td>
</tr>
<tr>
<td>7</td>
<td>The teacher can respond to student questions in a timely manner and provide a suitable answer</td>
<td>0.135</td>
<td>4.273</td>
</tr>
<tr>
<td>8</td>
<td>The teacher encourages class participation and the expression of ideas</td>
<td>0.230</td>
<td>4.209</td>
</tr>
<tr>
<td>9</td>
<td>The teacher can manage the flow of class content and ensure the students’ progress is on schedule</td>
<td>0.230</td>
<td>3.918</td>
</tr>
<tr>
<td>10</td>
<td>The teacher is not late, does not leave class early, change the time of classes, or miss classes without reason</td>
<td>0.581</td>
<td>4.600</td>
</tr>
<tr>
<td>11</td>
<td>The teacher considers teaching seriously and responsibly</td>
<td>0.046</td>
<td>4.491</td>
</tr>
<tr>
<td>12</td>
<td>The teacher’s lectures are presented clearly and are well structured, logical, and organized</td>
<td>0.068</td>
<td>4.245</td>
</tr>
<tr>
<td>13</td>
<td>The teacher understands the needs and difficulties experienced by students, and provides appropriate assistance</td>
<td>0.056</td>
<td>3.927</td>
</tr>
<tr>
<td>14</td>
<td>The teacher can provide constructive criticism and comments regarding the students’ assignments and examinations</td>
<td>0.230</td>
<td>3.918</td>
</tr>
<tr>
<td>15</td>
<td>The teacher can ensure that student evaluations are objective and reasonable</td>
<td>0.158</td>
<td>3.936</td>
</tr>
</tbody>
</table>
To better represent the level of importance and performance of each aspect, the results shown in Table 1 were graphed into an IPA grid, as shown in Fig. 2.

![Figure 2: Scatter Plot of the Importance-Performance Values for Each Teaching Element](image)

As shown in Fig. 2, the results of this study indicate that according to the responses of college students, all 15 teaching elements are located on the IPA graph.

Six of the elements, namely, 3, 4, 6, 9, 14, and 15, are scored within Quadrant A, which indicates that the students exhibited a low level of satisfaction, but placed high importance on the elements. Thus, these elements require the attention of the teacher, who should endeavor to improve them. Among the six elements in Quadrant A, Elements 9 and 14 are given the highest level of importance, but the lowest level of satisfaction. Thus, these two elements should be adjusted as soon as possible. In Quadrant B, Elements 8 and 10 were considered highly importance and provided high satisfaction. Thus, the teacher should maintain his or her methods regarding these elements. A single element is located in Quadrant C, that is, Element 13. This indicates that the element is considered to be of low importance, but also provides low satisfaction. Therefore, this aspect should be remedied, but should be given a lower priority. Quadrant D comprises 6 elements. These elements provided high satisfaction, but low importance, and can be considered a possible over-performance by the teacher. Element 11 is notable for providing a particularly high level of satisfaction but has among the lowest levels of importance. This is an example of possible overkill.

**CONCLUSION AND SUGGESTIONS**

The results of this case study suggest that the order of teaching elements that the teacher should improve should be “adjusting teaching style according to the level of students,” “organization and planning of educational activities,” “highlighting key points of the course content,” “managing the progress and flow of classes,” “providing constructive criticism and comments on student assignments and exams,” and “objective and reasonable student evaluations.” These are the elements that students hope the teacher can improve. Additionally, we also suggest that the teacher focus on improving these elements for future classes. After adopting changes, teachers should provide appropriate assistance and endeavor to understand the needs and difficulties encountered by the students. The results also indicate over-performance for the
following six elements: “use of metaphors, examples, and real-life cases to stimulate student cognition and interest,” “professional knowledge of the subject and the robustness of the course content,” “adequate preparation before class,” “lectures are presented clearly and are well structured, logical, and organized,” and “a sincere and responsible teaching attitude.” This is because these elements provided high satisfaction but were of low importance. Element 11, particularly, has the highest level of satisfaction but nearly the lowest level of importance; in other words, over-performance of the teacher.

For this study, we used a scale related to the level of importance. Typically, a questionnaire that measures only satisfaction or another similar trait is employed. However, such surveys only include one-sided answers. Thus, we adopted a variance-based measurement method, which we apply to the IPA method. Using this method of testing enables each teacher to target individual elements of their teaching by providing an importance-performance graph catered to their own teaching method. Teachers can then review students’ perceptions of the level of importance and satisfaction regarding elements of their teaching using the IPA graph. When the element is considered important but provides low satisfaction, adjustment is required. Conversely, when an aspect is considered of low importance but provides high satisfaction, it is possibly overemphasized, indicating over-performance in a specific area. Expending excessive effort ensuring high levels of satisfaction with elements of low importance is relatively meaningless. Similarly, if a specific element is of high importance, it does not necessarily mean that the teacher should invest all of his or her energy into perfecting that element because some of these elements are already performed to a satisfactory level. Therefore, both the level of importance and performance must be considered to devise an appropriate course of action.

REFERENCES


