ASSOCIATION ANALYSIS OF STUDENTS' DIVERSE ABILITIES

Menglu Cao, College of Engineering, California State Polytechnic University, Pomona, CA 91768, 626-764-2586, menglucao@cpp.edu
Wen Cheng, College of Engineering, California State Polytechnic University, Pomona, CA 91768 909-869-2957, wcheng@cpp.edu

ABSTRACT

Establishing a systematic evaluation of students' abilities in all aspects would be propitious to cultivate outstanding students with comprehensive development and would be helpful for students' lifelong learning and future career. This paper attempts to analyze the correlation between students' different capabilities from the outcomes of the Senior Exit Survey conducted on students about to obtain their undergraduate degree. The results indicated the existence of strong correlation among some student capacities.

Keywords: correlation, student self-evaluation, student capabilities.

INTRODUCTION

Effective student ability evaluation is essential to correctly guide the overall development of college students and provides decision-making direction and important basis for educators' instruction, management, and service. The application of self-evaluation is keeping increasing, "Self-evaluation (or self-assessment) is seen as a strategy which offers the opportunity for more learner-centered assessment practices, potentially focusing on broader issues such as professional development" [1]. College students are facing pressures in terms of study and employment. Undoubtedly, doing self-evaluation scientifically enable students to have a more specific understanding of their existing abilities. Self-evaluation would allow students to have a better recognition on their own shortcomings and advantages, and this would provide students an opportunity to ameliorate career planning for themselves based on their existing abilities. Furthermore, student assessment is one of the most effective means for educational institutions formulates targeted teaching programs. California State Polytechnic University, Pomona's Bachelor of Science in Civil Engineering (BSCE) program briefly described abilities that students are expected to obtain by the time of graduation, which relates to the skills, knowledge, and behaviors that students acquire in their matriculation through the program including problem-solving, engineering design, communication, experiment analysis, apply knowledge and so on [2]. Thus, students' self-evaluation survey was collected by the civil engineering department from students about to obtain their diploma. Two survey data combined increased the evaluation accuracy and the outcomes were used for measuring pre-graduate students' potential abilities and knowledge possessed.

Different from multiple studies did the research about self-evaluation influence on teaching scheme, our study sought to observe the relationship between students' diverse abilities, inspect whether different abilities can inhibit or promote each other. Afterward, it's possible to focus on improving a certain ability to enhance students' overall capability efficiently. In order to reach this goal, we investigated the correlation and significant difference between students' diverse abilities. In this paper, the Chi-Square test method was applied to examine the significance of diverse abilities and determined the Cramér's V (φ_C) value, which is a measure of association between two abilities.

Chi-square test is a common hypothesis test method based on X^2 distribution first proposed by British statistician Karl Pearson in 1900 [3]. It's mainly used to detect the degree of deviation between actual observations and theoretical inference values [4]. The larger the statistical value it calculates, the closer it is to the end of the distribution in the distribution, and the smaller the corresponding probability value would be. Even though various statistical normal distribution test methods had been developed such as T-test and F-test, we chose to use Chi-square test method because it is mostly used for comparison of multiple groups and multiple categories [5], which is perfectly corresponding to our data set since the survey outcomes of different questions are all categories variables.

In the study, Chi-square test method was used for determining the p-value represented the significant difference, then we employed the function in R studio to infer Cramér's V (φ_C) values to measure the association between two nominal variables, based on Pearson's chi-squared statistic published by Harald Cramér in 1946 [6]. Calculated Cramér's V values were applied to examine the correlation coefficient of students' self-scoring for two types of question about their own abilities, in order to discover the intercorrelation performance between different capabilities.

DATA DESCRPTION

In this project, both Senior Exit Survey data and Senior Project Assessment data are used to analyze and articulate ideas. The Department of Civil Engineering collects Senior Exit Survey data from students who are about to receive a diploma [2]. The senior project evaluation data is evaluated by the consultants after the students complete their senior projects. Student surveys include student names, enrollment status, time spent on CPP study, campus participation, work experience, licensing eligibility, and self-assessment of student achievement [8]. Table 1 below shows the 11 questions selected from the survey data as they represent the student's learning achievements. Advanced project assessments include different questions about student competency assessments, such as the ability to apply knowledge, the functional capabilities of interdisciplinary teams, the quality of presentations and communication, understanding of contemporary issues, and lifelong learning. Similarly, eleven questions that match the student are selected from the assessment and identified in Table 2.

Detailed description, the above 22 questions define the level of competence that engineering graduates should have under various conditions. In the student survey, each outcome has six possible answers: (0) not applicable; (1) poverty; (2) fairness; (3) average; (4) good; (5) excellent [8]. From 2013 to 2019, 662 people completed the survey. As for the assessment, unlike the student survey, the results have only five possible answers: (0) unobserved or not applied; (1) unacceptable; (2) marginal; (3) proficient; (4) model. From 2013 to 2019, a total of 424 consultants evaluated the seventh-grade students. Table 3 lists the detailed breakdown of the answers. The preliminary investigation of this study was to match the capacity assessment questions in the two surveys and to identify significant impacts between them. In order to make the two surveys comparable, we adjusted the answers to the two surveys.

Table 1. Questions Selected from the Senior Exit Survey

Question ID	Description of Student Learning Outcomes
a	Ability to apply knowledge of mathematics, science, and engineering.

b	Ability to design and conduct civil engineering experiments, as well as to analyze and interpret data.
c	Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
d	Ability to function on multidisciplinary teams.
e	Ability to identify, formulate, and solve engineering problems.
f	Understanding of professional and ethical responsibility.
g	Ability to communicate effectively.
h	Understanding of the impact of engineering solutions in a global, economic, environmental, and societal context.
i	Recognition of the need for, and an ability to engage in life-long learning.
j	Knowledge of contemporary issues and their importance to engineering systems.
k	Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table 2. Descriptive Statistics of Responses to Self-Evaluation of Student Outcomes

Question ID	**Count of Responses**							**Total Response Count**
	Excellent (5)	**Good (4)**	**Average (3)**	**Fair (2)**	**Poor (1)**	**N/A (0)**	**Rating Average***	
(a)	290	322	43	5	2	0	4.35	662
(b)	220	349	83	7	2	1	4.18	662
(c)	175	321	147	16	2	1	3.98	662
(d)	342	266	46	6	1	1	4.43	662
(e)	265	332	56	7	2	0	4.29	662
(f)	398	230	22	7	1	4	4.55	662
(g)	312	272	61	13	1	3	4.34	662
(h)	285	297	63	10	2	5	4.30	662
(i)	377	235	41	3	2	4	4.49	662
(j)	235	311	97	10	4	5	4.16	662
(k)	247	342	61	8	1	3	4.25	662

Notes: *: The rating average is calculated based on the scale of 0-5. The higher the ratings, the better the performance.

METHODOLOGY

The purpose of this paper is to analyze the correlation for different study ability of students. In order to accomplish this goal, we use the Chi-Square test investigated the test of goodness of fit. Then use the Carmer' V value to do the correlation analysis. As a common statistical model in data analysis, the Chi-

Square test is mainly to explore the relationship between nominal variable and nominal variable of categorical data type [10]. In our data sets, students' self-evaluation (S), which can be determined as the independent variable. And the scoring outcome, ranging from (3) to (1), is the dependent variable in this model.

3.1 Chi-Square test

The (Pearson) Chi-square test is very useful for testing the association or independence between categorical variables in a two-way contingency table. It is a non-parametric distribution-free statistic, following the hypothesis test which provides detailed information on the significance of any observed difference in the exact category. (Ker et al., 2005; Donnell et al, 2006; Dissanayake et al., 2002; Yang et al., 2009; Anderson et al.,2017; Hosmer & Lemeshow, 1989; Mchugh, 2013). The Chi-Square test statistic can be calculated using the following expression:

$$X^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \quad (1)$$

where n is the number of cells in the table, O is observed counts in the cell, E is the expected value of counts, $\chi 2$ is the Chi-Square value. The Chi-square distribution requires the degrees of freedom (df) in order to determine the significance level of the statistic. The df for Chi-square distribution can be evaluated with the formula:

$$df = (r-1) \times (c-1) \quad (2)$$

Where r represents the number of rows in the two-way table, and c represents the number of columns. Overall, it would be considered as a good model fit should the value of chi-square statistics divided by df is close to1.0, (Donnell et al., 2006).

3.2 Carmer's Von-Mises

A Cramer von-Mises type statistic is proposed for testing the symmetry of a continuous distribution function. Its asymptotic null distribution is found explicit, and its asymptotic distribution under a sequence of local alternatives is described.[9] Calculates the Cramer's V measure of effect size for chi-square tests of association and goodness of fit. The arguments to the cramersV function are all passed straight to the chisq.test function and should have the same format.

The Cramér-statistic is given by

$$T_{m,n} = \frac{mn}{m+n}\left[\frac{2}{mn}\sum_{i,j}^{m,n} \phi\left(\|\bar{X}_i - \bar{Y}_j\|^2\right) - \frac{1}{m^2}\sum_{i,j=1}^{m} \phi\left(\|\bar{X}_i - \bar{Y}_j\|^2\right) - \frac{1}{n^2}\sum_{i,j=1}^{n} \phi\left(\|\bar{X}_i - \bar{Y}_j\|^2\right)\right] \quad (3)$$

Where m is the number of *X* observation, n is the number of *Y* observation (Franz 2019).

RESULTS

In the R Studio software, Chi-square test method was applied by using the "chisq.test" function, then we can ascertain p-values displayed in Table 1. The p-values represent the significance between types of students' capabilities. The lower the p-value, the greater the significance between the two groups. And once the p-value is below 0.001, it means that the significance between the two groups is very large.

Table 1. Matrix of Chi-square test results

	a	b	c	d	e	f	g	h	i	j	k
a	NA	2.96e-263	2.23e-82	1.01e-96	2.56e-149	8.47e-33	7.41e-26	6.24e-37	5.88e-45	1.34e-34	4.48e-68
b	2.96e-263	NA	1.01e-91	1.05e-62	6.66e-142	4.49e-25	1.03e-22	1.62e-27	3.69e-32	3.83e-35	2.77e-59

c	2.23e-82	1.01e-91	NA	6.05e-82	3.11e-123	5.96e-92	1.81e-23	7.19e-76	4.43e-52	4.80e-107	3.39e-126
d	1.01e-96	1.05e-62	6.05e-82	NA	3.17e-96	2.20e-38	1.57e-45	7.85e-45	5.09e-40	6.44e-46	5.49e-57
e	2.56e-149	6.66e-142	3.11e-123	3.17e-96	NA	6.07e-24	2.64e-31	6.50e-69	3.56e-64	9.16e-48	3.06e-136
f	8.47e-33	4.49e-25	5.96e-92	2.20e-38	6.07e-24	NA	1.73e-62	1.10e-65	2.83e-71	1.44e-75	1.26e-51
g	7.41e-26	1.03e-22	1.81e-23	1.57e-45	2.64e-31	1.73e-62	NA	1.77e-54	8.10e-53	1.40e-48	4.14e-61
h	6.24e-37	1.62e-27	7.19e-76	7.85e-45	6.50e-69	1.10e-65	1.77e-54	NA	6.96e-119	9.91e-157	7.84e-146
i	5.88e-45	3.69e-32	4.43e-52	5.09e-40	3.56e-64	2.83e-71	8.10e-53	6.96e-119	NA	4.18e-97	1.07e-127
j	1.34e-34	3.83e-35	4.80e-107	6.44e-46	9.16e-48	1.44e-75	1.40e-48	9.91e-157	4.18e-97	NA	2.28e-132
k	4.48e-68	2.77e-59	3.39e-126	5.49e-57	3.06e-136	1.26e-51	4.14e-61	7.84e-146	1.07e-127	2.28e-132	NA

As shown in Table 1, all the p-values were below 0.01, which means all the capabilities evaluated in the Senior Exit Survey have a significant impact on each other. Moreover, the impact of two abilities examined by “a” and “b” was the most significant.

Cramér's V values placed in Table 2 were computed by function “assocstats” in R Studio software. The visual correlation coefficient matrix and the heatmap showed in Figure 1 and Figure 2.

Table 2. Matrix of Cramér's V Outcomes

	a	b	c	d	e	f	g	h	i	j	k
a	1.00	0.70	0.41	0.44	0.53	0.27	0.25	0.29	0.31	0.28	0.37
b	0.70	1.00	0.43	0.36	0.52	0.24	0.23	0.25	0.27	0.28	0.35
c	0.41	0.43	1.00	0.40	0.49	0.43	0.24	0.39	0.33	0.46	0.49
d	0.44	0.36	0.40	1.00	0.43	0.29	0.31	0.31	0.30	0.31	0.34
e	0.53	0.52	0.49	0.43	1.00	0.24	0.27	0.38	0.36	0.32	0.51
f	0.27	0.24	0.43	0.29	0.24	1.00	0.36	0.37	0.38	0.39	0.33
g	0.25	0.23	0.24	0.31	0.27	0.36	1.00	0.34	0.33	0.32	0.36
h	0.29	0.25	0.39	0.31	0.38	0.37	0.34	1.00	0.48	0.55	0.53
i	0.31	0.27	0.33	0.30	0.36	0.38	0.33	0.48	1.00	0.44	0.50
j	0.28	0.28	0.46	0.31	0.32	0.39	0.32	0.55	0.44	1.00	0.51
k	0.37	0.35	0.49	0.34	0.51	0.33	0.36	0.53	0.50	0.51	1.00
Avg	0.35	0.33	0.37	0.32	0.37	0.30	0.27	0.35	0.34	0.35	0.39

CONCLUSION

Self-knowledge of college students is the basis of individual self-knowledge. Self-concept and self-evaluation represent the level of self-knowledge and the core component of self-knowledge. Self-experience is the emotional experience that individual produce on his or her own self-evaluation. College students have a strong desire to design themselves and improve themselves. The self-knowledge, self-experience, and self-adjustment of college students are basically coordinated and synchronized, and the

self-awareness of college students has become an organic whole.

In this study, based on the p-values and Cramér's V outcomes, it's obvious that the growth of students' different abilities will affect and promote each other in the process of learning. Besides, the ability to use the techniques, skills, and modern engineering tools, plays an important role in improving overall capabilities. It helps students improve their overall ability faster and more efficiently. Nevertheless, our study still had some flaws since all the grades from the survey data were scoring by students themselves. These ratings cannot accurately represent the actual level of competence of students. Meanwhile, senior project advisor's assessments were subjective, and their scoring object was the group as a whole. It also cannot show the true ability of every student. Using added models and gathering more data reflecting students' true abilities in multiple aspects to do further analysis would be helpful for improving the accuracy of the results.

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