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Identifying Student-Focused Intervention Programmes through Discrimination Index

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Abstract

Discrimination index is one of the quantitative methods that seek to differentiate between students of high and low achievement by analysing their answers to examination questions at the end of their learning process. This assessment is done based on specific objectives such as identifying the level of students understanding on what they had learnt. Through discrimination index, various intervention programmes that students focused on can be proposed. Intervention programme must be designed according to the level of achievement of the students in the different groups and not based on the overall students' achievements of the particular cohort. This paper reports a study on discrimination index using index ratings on a final year design-based course at the Department of Mechanical and Material Engineering of Universiti Kebangsaan Malaysia. The calculated indices have been successful in identifying appropriate intervention programmes to suit students of low achievers in the course.

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Keywords: Discrimination Index; Intervention Programmes; Engineering Courses

1. Introduction

Discrimination Index as described by Hotiu (2006) is one of the important measuring tools in assessing the quality of an item that reflects the differences between students achievements, hence able to differentiate the level of excellence in that cohort of students. According to Mok Soon Sang (1995), discrimination index is used to differentiate the group of students with high and low achievements. This statement was noted earlier by Azman Wan Chik (1982) who claimed that discrimination index reflects each of the question assessed and differentiates the achievement between good and poor students. Among other methods that help to improve students achievement was through an Academic Advising Team intervention program (CORE) in which new students received counselling during their orientation. Through the counselling session, the instructor was able to identify problems experienced by new students (Patrick et al. 2011) Hence, initial steps to improve the quality of students can be implemented.

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Loon (2007) noted that by referring to the analysis of discrimination index, two hypotheses will be obtained namely; either the question is too hard even for the group of high achievers or the question is too easy even the group of students with lower achievements are capable of answering them correctly. Some of the purposes of discrimination index as highlighted by Anon (2006) are: 1) to identify the concepts that need to be taught again, as most of the students with high achievements are not able to answer correctly and 2) to identify the strength and weaknesses of parts of the curriculum, which can and cannot be dominated by the students, 3) to provide feedback to students with high achievements regarding their strengths and weaknesses on the topics assessed, 4) to identify the content bias questions, such as the topics that are not taught in class, 5) to guide students with high achievements to pursue their studies in a specific area. Mehrens and Lehmann (1984) reports that information gathered from the analysis of examination questions will allow for a better planning on the learning activities in the future. Through several assessments, it was found that students of a certain cohort vary in their achievement. In order to identify appropriate intervention programmes to improve the quality of students, it is imperative to focus on their differences. The existing practice is to provide a common intervention programme that may not suit all students. This approach may not be effective in terms of cost and quality improvement.

According to Anon (2006), the range of values for discrimination index is between -1.00 to +1.00. A positive discrimination index indicates that the number of students from the group of high achievers that answers the questions correctly is higher than the group of low achievers. On the other hand, a negative value of discrimination index indicates that the number of students from the group of lower achievers that answers the questions correctly are higher than the group of higher achievers. Table 1 shows the classification of difficulty index as proposed by Mok Soon Sang (1995), while Figure 1 provides a visual representation of the discrimination index.

Table 1. Classification of Discrimination Index (DI) and the Proposed action on the Item of Analysis.

Discrimination Index	Classification of Discrimination Level	Proposed Action
DI > 0.4	Good	Accept
0.2 < DI < 0.4	Moderate	Can be modified
0 < DI < 0.2	Low	Must modify
DI < 0	Negative	Must modify

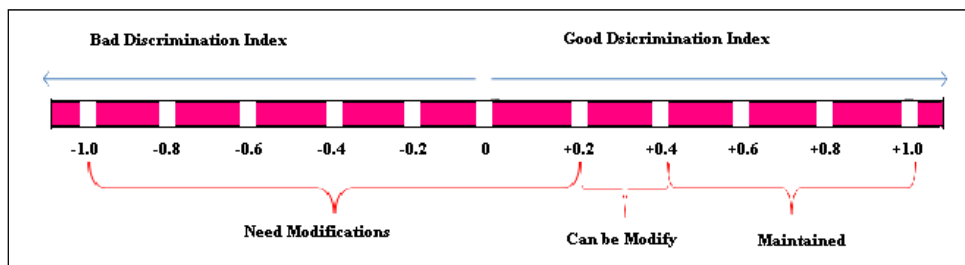


Figure 1. Relations between discrimination index, discrimination level and proposed action.

Anon (2006) noted that the value of discrimination index approaching +1.00 is good for the assessment of norm reference as it is capable of differentiating or discriminating the group of students of high and low achievements. Conversely, the value of discrimination index approaching negative is bad for the assessment of norm reference as it will wrongly interpret the outcomes, in which the numbers of low achievers who managed to answer correctly is higher than the group of high achievers.

According to Mehrens and Lehmann (1984), the outcomes of analysis have their own outstanding criteria. For example in this case, the outcomes of the discrimination index analysis are based on analysis of each item or question thereby boosting the quality of the examination questions. At the same time, improvements in terms of examination validations will be increased. On top of that, the analysis can be used to provide a solid planning on learning activities as well as to enhance the skills and experience in conducting examination in the future. It is therefore the aim of this study to identify students’ weaknesses in learning using Discrimination Index (DI) and to propose improvements in teaching and learning for the specific areas to enable students to achieve the required level of knowledge and competencies.

2. Methodology

There are several methods for determining the discrimination index for objective and subjective questions. This study will only focus on subjective questions with the following serving as a checklist for the parameters required to perform the calculation based on Technical Bulletin of Evaluation and Exam Service: The University of Iowa (www.uiowa.edu):

- i. Division ratio of 25% respectively for the number of students in the high and low achievement groups.
- ii. The total scores of 25% respectively for the students in both high and low achievement groups.
- iii. The value of N, referring to a ratio of 25% for the total students being tested.
- iv. The maximum score ($Score_{max}$) and minimum score ($Score_{min}$) value for each of the question tested.

Next is to apply the approach shown below as in Technical Bulletin of Evaluation and Exam Service: The University of Iowa (www.uiowa.edu):

- i. To identify the proportions of 25% for both groups of students with high and low achievements in a cohort being assessed. Both groups are identified as (*H*) for the groups of students with high achievements and (*L*) for the groups of students with low achievements respectively.
- ii. Next is to calculate the total scores for each of the questions tested for the group of students with high achievements ($\sum H$ – sum of scores for upper 25%) and for the groups of students with low achievements ($\sum L$ – sum of scores for lower 25%).
- iii. Lastly is to apply all the gathered data into the discrimination index formula.

$$\text{Discrimination Index} = \left[\frac{\sum H - \sum L}{N(Score_{max} - Score_{min})} \right] \quad (1)$$

$\sum H$ = total score for 25% of students in the high achievement group.

$\sum L$ = total score for 25% of students in the low achievement group.

N = 25% of total numbers of student tested.

$Score_{max}$ = maximum (full) marks for the question.

$Score_{min}$ = minimum marks for the question.

3. Results and Discussion

For the purpose of this study, a design based course for final year undergraduate students of the Manufacturing Engineering programme was selected as a case study. The undergraduate course, KKKP4213 Automation and Robotics has a final examination as one of the assessment component. This study focuses on Part A of the examination paper comprising of compulsory questions.

In order to obtain the discrimination index, the marks obtained by all students are arranged in descending order as presented in Appendix A. The procedure for calculating discrimination index is according to the method shown in equation (1). Data in Appendix A shows the high achiever group and the low achiever group of students using the limit suggested in the method.

Table 2 presents a summary of the raw data that indicates the 25% of the high achiever group and low achiever group from the total number of student. The students are listed according to their identification number (ID) as shown in Appendix A, as well as the number of students tested (N). The total number of students for the course is 36 and in order to ensure validity of the formula for discrimination index, a 25% ratio from the total number of students must be taken into consideration. In this case, for KKKP4213, the 25% ratio from the total number of students is 9.

Table 2. Summary of the raw data

Course	Total no. of students	25% ratio of the number of students (N)	Student ID	
			H	L
KKKP4213	36	9	P1 – 9	P28 – P36

Table 3 comprised the total marks and the marks obtained by the 25% high achiever and low achiever group ($\sum H$ and $\sum L$) for every examination question. The lowest marks ($Score_{min}$) for each question are not presented since all of the lowest marks are of zero value.

Table 3. Summary of the marks obtained for KKKP4213

	KKKP4213 Examination Questions					
	Q1	Q2	Q3	Q4	Q5	Q6
Total Marks ($Score_{max}$)	10	7	5	10	8	10
Total marks for H ($\sum H$)	76	52	27	11	47	84
Total marks for L ($\sum L$)	22	34	13	4	27	14.5
Discrimination Index (DI)	0.60	0.29	0.31	0.08	0.28	0.77

The following is an example for calculating discrimination index for Question 1 (Q1) using equation (1).

$$\begin{aligned} \text{Total marks for the high achiever group } (\sum H) &= 10+10+10+10+10+8+8+5+5 \\ &= \mathbf{76 \text{ marks}} \end{aligned}$$

$$\begin{aligned} \text{Total marks for the low achiever group } (\sum L) &= 5+0+3+1+4+5+1+1+2 \\ &= \mathbf{22 \text{ marks}} \end{aligned}$$

$$\begin{aligned} \text{Total number of students } \times 25\% (N) \\ &= 36 \times \left[\frac{25}{100} \right] = \mathbf{9} \end{aligned}$$

$$\begin{aligned} \text{Discrimination Index} &= \left[\frac{\sum H - \sum L}{N(Score_{max} - Score_{min})} \right] \\ &= \left[\frac{76 - 22}{9(10 - 0)} \right] = \left[\frac{54}{9(10)} \right] = \mathbf{0.60} \end{aligned}$$

Table 4 shows the results of analysis and interpretation of discrimination index based on Table 1, which is the discrimination index classification proposed by Mok Soon Sang (1995).

Table 4. Analysis and Interpretation of Discrimination Index for KKKP4213

Question No.	Discrimination Index	Interpretation	Results
Q1	0.60	Good positive discrimination	Good question
Q2	0.29	Average positive discrimination	Easy question but acceptable
Q3	0.31	Average positive discrimination	Easy question but acceptable
Q4	0.08	Low positive discrimination	Easy question but not able to differentiate between high and lower achievers
Q5	0.28	Average positive discrimination	Easy question but acceptable
Q6	0.77	Good positive discrimination	Good question

There are altogether 6 questions in Part A of the final examination of KKP4213. Overall, the results of analysis on discrimination index for KKKP4213 is very encouraging. The results shown in Table 4 shows two out of six questions attained a high discrimination index, namely Q1 and Q6. The index indicates that the questions have successfully differentiated the high from the low achievers in terms of their achievement. On the other hand, Q4 attained a low discrimination index which implies that the question was not able to differentiate the two groups of students. It is therefore recommended that Q4 be reviewed.

Questions with low discrimination however, may be given to students in order to allow them to answer correctly. Meanwhile, it is rational for students to be given difficult questions in order to test their level of knowledge on the subject as in the case of Q1 and Q6. It is recommended that similar questions or questions of that level be retained in future examinations.

The discrimination index of Q2, Q3 and Q5 are 0.29, 0.31 and 0.28 respectively and are considered as average. These values indicate that the questions are acceptable and similar questions can be used in future examinations. However, Q4 was recommended to be modified since it is not able to differentiate students with high achievement to those of low achievement. It was also noted from the analysis that there are no questions with a negative discrimination index.

4. Relations Between Discrimination Index And Student-Focused Intervention Programme

The achievement of a student can be assessed through examinations whereby an academician can assist them through other delivery methods such as discussions and seminars. Assessment through examination is aimed at monitoring students' academic expansion as well as on their generic skills. Using discrimination index as the item of analysis, students' weaknesses can be identified based on comparison between the type of question and the marks obtained by each individual student. For example, from this study it was found that Q1 and Q6 are able to differentiate between the high achiever from the lower achiever group. Q1 and Q6 were further analysed and it was found that the questions require the following abilities:

Q1 – Understanding design configuration, assembly including spatial.

Q6 – Ability to synthesize and represent information.

The above knowledge and ability which are related to the aspects of design synthesis are necessary in any design course. The process of design synthesis involves the generation of information in qualitative form and hard to capture in a computer system. It does not only require in-depth technical knowledge but also skills on problem solving and creativity. The process of design analysis, on the other hand is much more supported by advanced computer aided tools and methods.

From this analysis, academicians can therefore propose appropriate intervention programmes to enhance students' knowledge on design synthesis. Intervention programmes may include more discussions and exercises to enhance problem solving and creativity through the use of relevant techniques and approaches.

5. Conclusions

This paper reports a study aimed at relating discrimination index of examination questions to the improvement of students' achievement through student focused intervention programmes using a simple quantitative method. The programme can lead to knowledge and skills enhancement relating to concepts and fundamentals, applications, current issues, mastering of current analysis software etc. It is hoped that this study will open up for more detailed research on the item of analysis and enhancement of students' achievement in total.

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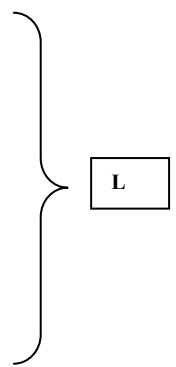
Appendix A: Marking Scores for KKKP4213

KKKP4213 (N=36)							
	Questions						Total Scores (50 marks)
	Q1 (10 marks)	Q2 (7 marks)	Q3 (5 marks)	Q4 (10 marks)	Q5 (8 marks)	Q6 (10 marks)	
P1	10	6	5	5	8	10	44
P2	10	5	3	6	8	9	41
P3	10	7	3	0	6	10	36
P4	10	4	3	0	6	10	33
P5	10	5	3	0	3	10	31
P6	8	7	2	0	3	10	30
P7	8	6	3	0	3	8	28
P8	5	6	3	0	7	7	28
P9	5	6	2	0	3	10	26
P10	4	5	3	0	3	9	24
P11	8	5	3	0	0	8	24
P12	1	6	3	0	3	10	23
P13	3	5	2	0	3	10	23
P14	7.5	5	3	0	0	7	22.5
P15	6	5	3	0	6	0	20
P16	8	7	2	0	3	0	20
P17	5	6	3	0	5	0	19
P18	0	7	3	0	6	3	19
P19	0	6	3	0	8	2	19
P20	4	6	3	0	3	2	18
P21	5	6	4	0	3	0	18



H

KKKP4213 (N=36)							
	Questions						Total Scores (50 marks)
	Q1 (10 marks)	Q2 (7 marks)	Q3 (5 marks)	Q4 (10 marks)	Q5 (8 marks)	Q6 (10 marks)	
P22	6	5	3	0	3	0	17
P23	3	5	3	0	6	0	17
P24	4	4	3	0	3	3	17
P25	4	6	3	0	3	0	16
P26	3	7	3	0	3	0	16
P27	6	7	0	0	3	0	16
P28	5	5	3	0	3	0	16
P29	0	3	1	0	3	8.5	15.5
P30	3	3	2	4	3	0	15
P31	1	4	0	0	3	6	14
P32	4	2	3	0	3	0	12
P33	5	3	1	0	3	0	12
P34	1	4	3	0	3	0	11
P35	1	6	0	0	3	0	10
P36	2	4	0	0	3	0	9
ΣH	76	52	27	11	47	84	
ΣL	22	34	13	4	27	14.5	
DI	0.60	0.29	0.31	0.08	0.28	0.77	



*P = Students ID
 *DI = Discrimination Index