

1. INTRODUCTION

Recently, many researchers have focused their interest to use different assessment and evaluation techniques to maximize the educational process effectiveness and to improve the Intended learning outcomes (ILOs). This paper presents the newly applied hybrid education method used for design of firefighting systems inside non-residential buildings. The hybrid educational methods have become more widely used in engineering education post COVID-19 Pandemic. Assessment and academic evaluation play a pivotal role in any education system, (Ali, et al., 2020; Mccowan & Mccowan, 1999). These assessments not only precisely measure what students do or do not know but also help to identify any alternative instructional approaches to improve understanding of candidates (Alam, et al., 2011; Khan, 2012). In educational assessments, multi response questions (MRQs) were strongly preferred testing instrument across many educational systems (Clarke, et al., 2005). Assessment and evaluation system affect teaching and learning in different ways and at different stages by creating a feedback effect if these are valid and reliable (Zhang, et al., 2014).

Multiple choice questions (MCQs) are frequently utilized to provide teachers with the feedback on their educational methodologies and tools. MCQs should be carefully designed to be used for comprehensive assessment either in formative assessments or in summative assessments at the end of academic semesters. Taib, et al., (2014) recommended that MCQs always need to be checked and tested periodically for the quality and the standards. The MCQs design process should be performed carefully taking into considerations how to measure and assess students level in their different educational streams for wide range of coverage and objectivity in less time. Item analysis examines

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the student responses to individual test items (MCQ) to assess the quality of those items and test as a whole. Item analysis assesses the assessment tool for the benefit of both student and teacher. Vegada et al. (2016) have conducted a comparative study between three option, four option, and five option MCQ tests for quality parameter. They concluded that assessment based on three option MCQs can be preferred over four option and five option MCQs.

Mouneer (2019) conducted a comprehensive study to present how MCQs can be used to assessing and measure the students' levels during formative and summative exams for engineering course. This study presented also how the newly methods of assessment and evaluation can be disseminated among different department of engineering by performing a number of research based projects to help assessing process and remarking tools by undergraduate students. Sajitha et al. (2015) presented a study on the role of item analysis in post validation of MCQs in formative assessment of medical students. They found that the study emphasizes on the importance of use of item analysis in construction of good quality MCQs and in the evaluation of learner performance. Khilnani et al. (2019) have developed MCQ bank in otorhinolaryngology by item analysis during their cross-sectional study. They concluded that a valid and reliable MCQ question bank can be developed based on the results of item analysis which should be an integral and regular activity in each department. Sar et al. (2018) conducted an item analysis for nursing education. Their study aimed at performing item analysis of three MCQs exams and finding the relationship between the item difficulty and the number of non-functioning distractors (NFDs).

Mahjabeen et al. (2018) performed a cross sectional study to evaluate the quality of MCQs by analyzing difficulty index, discrimination index and distractor efficiency. They found out the

association of MCQs having good difficulty and discrimination indices with distractor efficiency. Their Study was conducted at department of Pathology, Islamabad medical and dental college. Toksöz and Ertunç (2017) conducted an item analysis of MCQ exam in language and literary studies. They found that most of used items were at moderate level and their results classified 28% of the items in low item discrimination value. They analyzed the distractor efficiency and it has been found that some distractors in the assessment were ineffective and must be excluded or carefully revised before performing the next exam. Talebi et al. (2016) presented item analysis as an effective tool for assessing exam quality, designing appropriate exam, and determining weakness in teaching. They concluded that the item analysis should be followed by revised and improved teaching method.

Epstein (2007) described competence as a habit of lifelong learning, contextual that reflecting person ability to performing tasks and developmental in nature, where it is a result of a well-planned practice and reflection on own experience. Many medical education programs and licensing authorities either at undergraduate level or postgraduate level have paid an observed attention and efforts to validate and to ensure the authenticity of assessments of students and competency of trainees (Karim, et al., 2009; Newble, 1992). Every assessment format has its advantages and disadvantages depending on the assessment design. The best assessment method must meet five criteria which include reliability, validity, acceptability, feasibility and educational impacts on learning and practice (Habib, et al., 2016; Patil, et al., 2016). Rao et al. (2016) presented an item analysis of MCQs to assess an assessment tool in medical students. The results of their study aimed to initiate a change in the way MCQ test items which to be selected for any examination, and there should be proper assessment strategy as part of the curriculum development.

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Upoadhyah et al. (2019) conducted an analysis of one best MCQs in five pre-university physiology examinations. The objective of their study was to analyze the MCQs used in preliminary examinations in terms of difficulty index, differentiation index and distracter efficiency. Miller (1990) classified assessment methods into four types, which were include assessing knowledge (knows), assessing ability to apply knowledge within its context (knows how), assessing trainees' performance in simulated environment (show how) and assessing trainees' performance in actual environment (does). The (does) component was considered as the most difficult area to be examined authentically. The difficulty level and discriminating index of stem type multiple choice questions of anatomy have been studied in Rajkot by Chauhan et al. (2013). Their study concluded that test papers were good to excellent to discriminate and of acceptable range of difficulty. Patil et al. (2016) conducted evaluation study of MCQs by item analysis in a medical college at Pondicherry in India. They found that there were only three MCQs out of the total 30 MCQs which satisfied all the criteria for an ideal MCQ.

The main objective of this article is to present the benefits of using hybrid education method under the force major conditions of COVID-19 during Spring 2020 semester, in Egyptian universities. The selected faculty to perform this comprehensive study is faculty of engineering, in Benha university (BU), in Egypt. A Firefighting system course is selected carefully among the courses educated using hybrid education method. The face-to-face learning strategies have been used for the first month in that spring semester, then online learning methods were followed during COVID-19 pandemic until the summative examinations performed in August 2020, for two groups of students of credit hour engineering program (CHEP), and mainstream students. The

summative examination methodologies are varied for both students' groups, by using open book exam (OBE) for CHEP students and using written summative exam (WSE) for main stream students. The problem-based learning method is carefully used to measure and assess the ILOs for the selected firefighting systems course. However, MRQs are used with six different types in written summative exam performed by mainstream students of fourth level, B.Sc. graduation stage. The second objective of this current research is to perform an item analysis for the used multi response questions. The current research plan on hybrid education method and its items analysis under COVID-19 pandemic are presented in Figure 1. The performed examination procedures, and types are also listed in this figure.

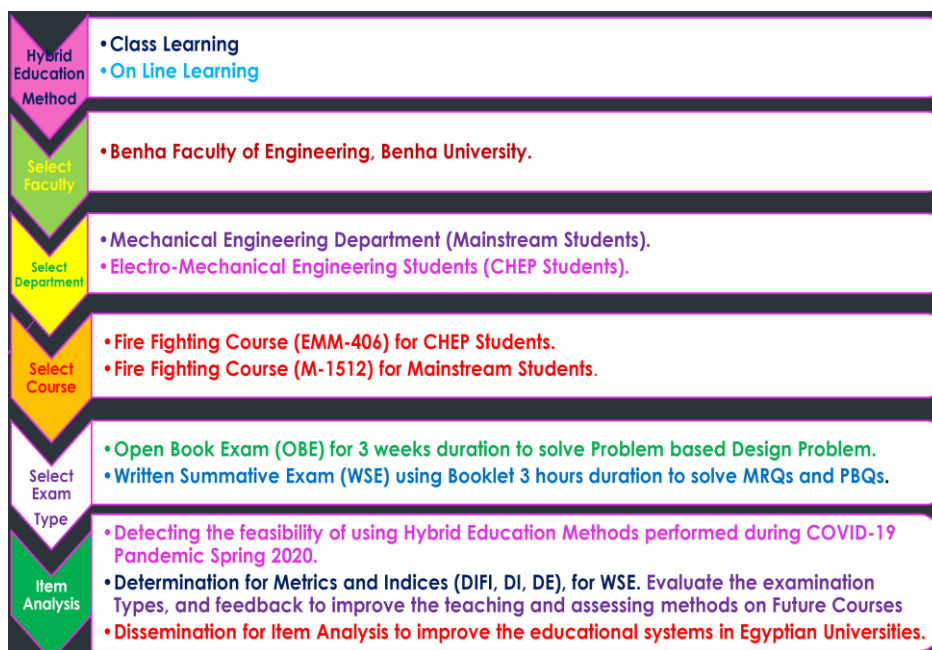


Figure1: Research plan for hybrid educational methods performed in spring 2020, during COVID-19 pandemic.

2. RESEARCH METHODOLOGY

In this section, some basic definitions, metrics, and indices used in measurements and evaluation field are presented. The key measuring indices include i) Difficulty index (DIFI), ii) Discrimination index (DI), and iii) Distractor Efficiency. These dimensionless indices are commonly used to detect and evaluate the performance of examination processes, to improve and check the validity of both teaching methods and assessment methods. A modified hybrid educational method is recently highlighted and recommended by many countries to overcome the educational process delays, which might be expected due to pandemic namely COVID-19, investigated early in 2020 among all the world countries. The hybrid educational method is depending on both online and on class learning together, to gain both advantageous of these commonly used learning approaches, in safely conditions for all elements of educational process. Hybrid educational method can solve these kinds of direct contact problems between students, teachers, and administration in classroom, examination halls, and also in means of transportation. The ILOs of the firefighting systems course are presented in subsection 2.1. Then the measurements and evaluation metrics commonly used for item analysis is demonstrated in subsection 2.2. Both of performed summative exams either OBEs or WSEs and their requirements are listed, specified and compared in subsection 2.3. The proposed problem based question and its technical data and architecture drawings for the hotel building are demonstrated in subsections 2.4.

2.1 Detection for intended learning outcomes (ILOs)

The examination processes have been carefully designed to apply all the ILOs of these courses by perform mechanical design

problems to issue the design of a firefighting system for one of non-residential buildings such as hotel building. It should be clear that the quality examination is commonly based on the key features of validity and reliability of either research based using OBEs or problem based using questions listed in answer sheet booklet designed by staff members.

The MCQ items are the key components of most advanced question papers specially in medicine and engineering. The field testing and post exam analysis should be paid by all educational process elements to ensure the fitness of these items, using standard measurement and evaluation metrics and indices. Based on these metrics and their attributes, these questions shall be declared fit items for future use and improve, or unfit items for future discard or revise. Table 1 demonstrates ILOs, course specifications and requirements for the firefighting system under design considerations for both group of students, CHEP students (Coded EMM-406) and mainstream students (Coded M-1512). It should be clear from Table 1 that ILOs re classified into many consequent steps including proper selection and calculations of firefighting systems and components, understanding applied standards and codes, design and calculation for piping systems on riser diagrams and plan drawings, and preparing conceptual design reports.

Table 1: ILOs for firefighting systems courses for both students' groups, CHEP students and main stream students.

Comparison Item	CHEP students	Mainstream students
Course Code	EMM-406	M-1512
•ILOs		
1. Proper design of firefighting systems, e.g. how to size and design components.	•	•

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Comparison Item	CHEP students	Mainstream students
2. Better understanding of standards, codes, and regulations.	•	•
3. Calculating demands, e.g., fire water tanks & pumping unit capacities.	•	•
4. Design and calculation on firefighting piping system: sizing and pressure losses.	•	•
5. Selection and design of fire Fighting systems and system components.	•	•
6. Prepare design drawings such riser diagrams, plan views and calculation notes, and conceptual design reports.	•	•

2.2 Measurement and evaluation indices and metrics

Difficulty index (DIFI) is known as item difficulty refers to the percentage of people who have responded to a question correctly. DIFI has established the content validity. DIFI of each question was determined using the formula presented in Table 2, which has firstly presented by Crocker & Algina (1986). As an index, its value ranges between 0 (when none of the examinees answered the question correct) and 1.0 (where all the examinees got the question right), as reported by Mccowan & Mccowan (1999). For classification DIFI values, questions with low difficulty (i.e., easy questions with DIFI value 0.8 or more) and very high difficulty (i.e., difficult questions with DIFI value 0.2 or lesser) in each subject.

Discrimination index (DI) is a comparison of performance of higher ability group (HAG), (higher 30%) and low ability group (LAG), (lower 30%) in the whole test on a particular question, as reported by Taib et al. (2014). As an index, its values range between -1.00 and $+1.00$. The DI value for each question was also determined using Kelley's method (Mccowan & Mccowan, 1999;

Taib, et al., 2014; Patil, et al., 2016). The DI of each question was determined using the expression presented by Mccowan & Mccowan (1999) and by Taib et al. (2014), and listed in Table 2.

Distractor efficiency (DE) refers to the number of non-functional distractors (NFDs) or unutilized incorrect option (distractor) in an MCQ. Whereas an NFD is an incorrect option (distractor) opted by very few students. The DE emphasizes the functionality of a distractor in a question. DE value ranges between 0.0% and 100%, that is, a distractor opted by 5% or lesser number of candidates was declared a NFD, as reported by Kheyami et al. (2018). Hence, the DE of each question was calculated by using formula presented in Table 2.

Table 2: Definitions and formulas for item analysis metrics.

Analysis parameters	Formula	Result range	References
Difficulty Index (DIFI)	$DIFI = (H+L)/N$	- >30 (too difficult) - 30-70 (moderate) - >70 (too easy)	Crocker & Algina (1986)
Discrimination Index (DI)	$DI = (H-L)/N$	- <0.15 (poor) - 0.15-<0.25 (good) - >0.25 (Excellent)	Taib et al. (2014) Garg et al. (2019)
Distractor Efficiency (DE)	$DE = M/N$	- <5% (poor distractor) NFD - >5% (functional distractor) FD	Suryadevara & Bano (2018)

2.3 Specifications for Summative Examination Methods

Table 3 depicts the technical specifications and requirements for the firefighting systems requested from both student's groups, CHEP students and main stream students, to design the

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firefighting systems for hotel building consists of podium and tower for guest rooms typical floors. For the first group of CHEP Students, each student was requested to prepare his/her conceptual design report for the firefighting works for this hotel building in not more than 10 pages, meanwhile, for the second group of mainstream students, each student was requested to perform the scheduled written examination using the answer booklet pre-designed by staff members.

Table 3: Technical specifications for problem-based questions (PBQs) on firefighting systems for both students' groups, CHEP students and main stream students.

Comparison item		CHEP students	Mainstream students
Course code		EMM-406	M-1512
•Hotel building technical data			
No. of typical floors for guest rooms	Floor	26	5
No. of basement floors for services	Floor	3	3
Floor slab to slab height	m	3	3
Requested firefighting pumping systems	System	2	1
No. of guest rooms per typical floor	Room	20	20
No. of mechanical shafts available	Shafts	2	2
Smoke management system requested	Yes/No	N/R	Requested
List of all firefighting systems	Yes/No	Requested	Requested
•Firefighting systems & System components			
Automatic sprinkler systems (Wet/ Dry)	Guest rooms, & Elevator lobbies		
Fire hose cabinet systems	Open spaces, & Staircases		
Clean agent gases systems (Total flooding / Local applications)	IT Rooms, Data centres		
Carbon dioxide firefighting systems	Transformers, & MDB rooms		
Wet chemical systems	Main kitchens, & Pantries		
•Examination structure			
Examination style		OBE	WSE
Examination duration		2-Weeks	3 hours
Examination method		On-Line	Booklet

2.4 Selection for design-based problems

In this current investigation, the examination procedures for firefighting systems have been focused on a model of typical hotel building located in Cairo city on Nile river consists of 2 basements (B1+B2), ground floor (G), 26 typical floors (from 1st floor to 26th floor), and the roof annex, as can be seen in Figure 2, for Sofitel Cairo Nile El-Gezirah Hotel (2020). Each of the typical floor consists of 20 guest rooms (numbered by including the floor number).

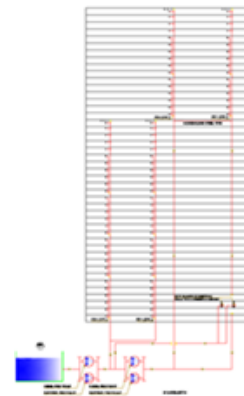
a) Bird view for hotel building by Abbas (2019).



b) Space program for hotel

c) Firefighting Riser diagram

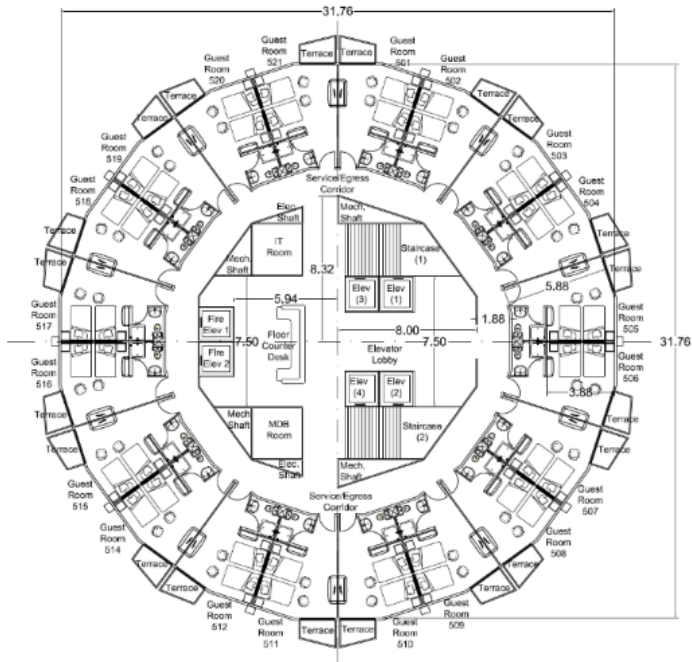
Public Water Tanks - Elevator Machine Room		
Roof Annex		Roof Annex
10 th floor	Cairo Rooms 1001 1021 - Elevator Lobby + 3200 + 11 Room	10 th floor
10 th floor	Cairo Rooms 1001 1021 - Elevator Lobby + 3200 + 11 Room	10 th floor
12 th floor	Cairo Rooms 1201 1221 - Elevator Lobby + 3200 + 11 Room	12 th floor
12 th floor	Cairo Rooms 1201 1221 - Elevator Lobby + 3200 + 11 Room	12 th floor
14 th floor	Cairo Rooms 1401 1421 - Elevator Lobby + 3200 + 11 Room	14 th floor
14 th floor	Cairo Rooms 1401 1421 - Elevator Lobby + 3200 + 11 Room	14 th floor
16 th floor	Cairo Rooms 1601 1621 - Elevator Lobby + 3200 + 11 Room	16 th floor
16 th floor	Cairo Rooms 1601 1621 - Elevator Lobby + 3200 + 11 Room	16 th floor
18 th floor	Cairo Rooms 1801 1821 - Elevator Lobby + 3200 + 11 Room	18 th floor
18 th floor	Cairo Rooms 1801 1821 - Elevator Lobby + 3200 + 11 Room	18 th floor
20 th floor	Cairo Rooms 2001 2021 - Elevator Lobby + 3200 + 11 Room	20 th floor
20 th floor	Cairo Rooms 2001 2021 - Elevator Lobby + 3200 + 11 Room	20 th floor
22 th floor	Cairo Rooms 2201 2221 - Elevator Lobby + 3200 + 11 Room	22 th floor
22 th floor	Cairo Rooms 2201 2221 - Elevator Lobby + 3200 + 11 Room	22 th floor
24 th floor	Cairo Rooms 2401 2421 - Elevator Lobby + 3200 + 11 Room	24 th floor
24 th floor	Cairo Rooms 2401 2421 - Elevator Lobby + 3200 + 11 Room	24 th floor
26 th floor	Cairo Rooms 2601 2621 - Elevator Lobby + 3200 + 11 Room	26 th floor
26 th floor	Cairo Rooms 2601 2621 - Elevator Lobby + 3200 + 11 Room	26 th floor
Roof Annex	Roof Annex	Roof Annex
Basement 1	Shop + Electrical room + 3200 room	Basement 1
Basement 2	Food Bank + Fire Pump Room + Waste Tank + Diesel Generator Set + Transformer	Basement 2



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Figure 2: Sofitel Cairo Nile El-Gezirah Hotel (2020), a) bird view by Abbas (2019), b) space program, c) riser diagrams.

d) Architecture Plan view for typical floor (20 guest rooms).



e) Firefighting system for typical floor (by course editor).



Figure 2 (Cont.): Sofitel Cairo Nile El-Gezira Hotel (2020), d) architecture plan view, and e) firefighting system for typical floor (by course editor).

3. ASSESSMENT AND EVALUATION TOOLS

This section presents the assessing tools used to evaluate the student's level during summative exams. The exams are basically based on OBE and WSE. The performed summative assessment was based on both types of questions, multi response question and problem-based questions.

3.1 Multi Response Questions (MRQs)

MRQs are classified during performed WSE into six main groups, which could be namely MCQs, T/FQs, FSQs, EMQs, RANQs, and FRSAQs. Table 2 depicts the MCQs questions (Q 1.1) presented to student on firefighting summative exam performed in recently in August 2020, after COVID-19 reopening.

These MCQs are measuring the knowledge and understanding for firefighting systems, their system components, theory of operation, applied codes and standards, and the main features of firefighting design. Table 3 depicts the True/False Question (T/FQ) and Fill in space questions (FSQ), Q 1.2 and 1.3 respectively, presented to measuring the knowledge and understanding for, applied codes and standards, and firefighting systems components. Table 4 depicts the extended matching question (EMQs) and ranking questions RANQ, Q 2.1 and 2.2 respectively, presented to measuring the basis of design as per applied codes and standards, and firefighting systems components. Table 4 presents several free response short answers question FRSAQ (Q 2.3) on design issues such as estimate the fire water demand for different kind of non-residential building as per applied codes, and authority having jurisdiction.

3.2 Mechanical design Problem Based Questions (PBQs)

Figure 3-a, b presents many samples of students' answer, which also can be considered as model answer for problem-based questions (PBQs) and essay questions (Q36-a) These PBQs which request the students to list, select and tabulate each of the recommended firefighting systems for all prescribed spaces inside hotel building floor. Figure 3-c, d demonstrate the model answer for Question 36-b, which requested to plot of firefighting riser diagram for hotel building floors on the building sectional view attached into answer booklet. This figure presents two alternatives of model answers for question 37-a, which requested to design and plot the water sprinklers firefighting systems on typical floor of hotel building on plan view attached into answer booklet. Figure 3-e shows the model answer for question 38-a of smoke management riser diagram for hotel building floors.

a) OBE using MS Excel.

no.	Space	Hazard Type	fire fighting System	Sub-System	System Component
Basement 2					
1	car park	ordinary	Sprinkler System	Wet	upright sprinkler-piping -fitting-PRVs-flow switch
2	pump room	light			
3	water tanks	N/A	N/A	N/A	N/A
4	Diesel generating set	ordinary	Foam system	Foam	vertical style bladder tank-strainer - piping and fittings
5	Transformers	ordinary	Gas System	Dry	welder + F.E. 6kg Co2+heat detector+alarm bell+abort switch+Man...
Basement 1					
6	Shops	light	Sprinkler System	Wet	Concealed Pendant Sprinkler-piping -fitting-PRVs-flow switch
7	Electrical room	light	Gas System	Dry	F.E. 6kg auto dry powder
8	MDB room	light			Fire search 6kg Co2 F.E.
9	Reception	light	Sprinkler System	Wet	Concealed Pendant Sprinkler-piping -fitting-PRVs-flow switch
10	Restaurant kitchen	ordinary			wet chemical sys. On the hood (UL300 Approved)
11	Restaurant hall	light			Concealed Pendant Sprinkler-piping -fitting-PRVs-flow switch
from 1st floor to 28th floor					
12	Guest rooms	light	Sprinkler System	Wet	Side wall Sprinkler-piping -fitting-PRVs-flow switch
13	Elevator Lobby	light			Concealed Pendant Sprinkler-piping -fitting-PRVs-flow switch
14	MDB rooms	light	Gas System	Dry	Fire search 6kg Co2 F.E.
15	IT rooms	ordinary			FM 200 System
Roof Annex					
16	Potable Water Tanks	N/A	N/A	N/A	N/A
17	Elevators Machine Room	ordinary	Gas System	Dry	FM 200 System

b) mainstream during (WSE).

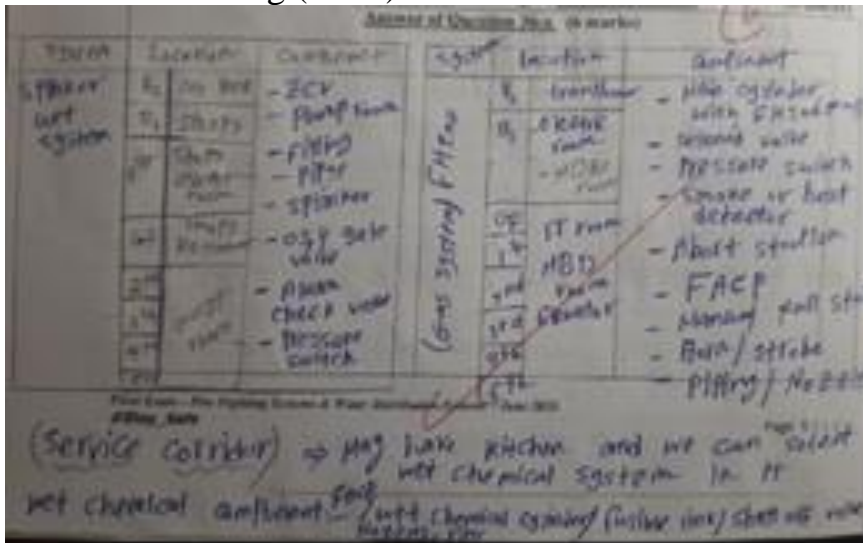
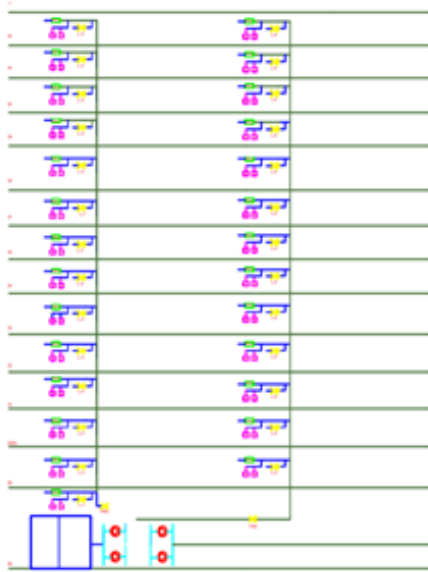


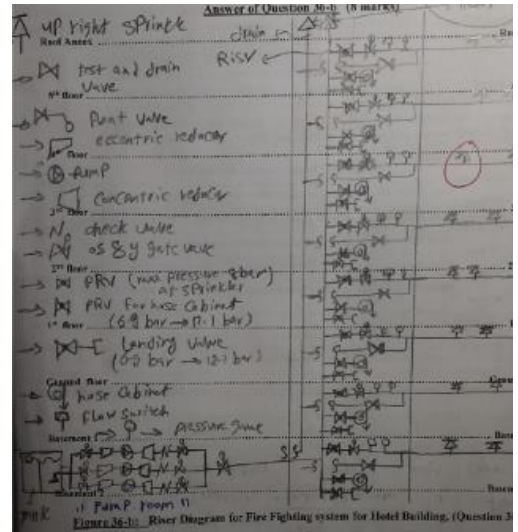
Figure 3: Selective students' answers for a) CHEP students, b) mainstream students (2020).

c) OBE Spring 2020 using CAD. e) mainstream during (WSE).

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d) OBE Spring 2020 using CAD.



f) mainstream during (WSE) Aug 2020.

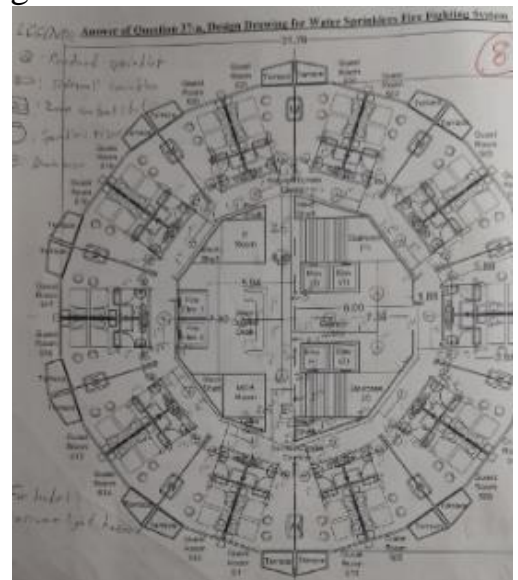
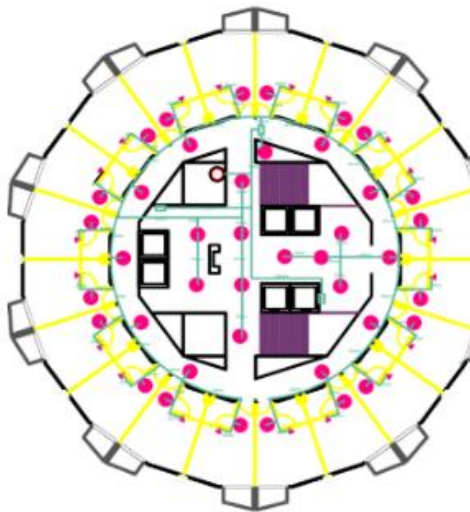


Figure 3 (Cont.): Selective students' answers for c) & d) CHEP students, e) & f) mainstream students (2020).

3.3 Estimation of Difficulty, and Discrimination Indices

The MRQs are classified into six types such MCQ, T/F, fill in space, matching, ranking, and short answer problems, however, the essay questions have been carefully designed to measure the mechanical design problems and their ILOs.

Table 4: Mean values for score, DIFI, DI, and DE for MCQs and PBQs.

Question No.	Question Type	No. of items	Full Mark	Mean Score	Mean DIFI %	Mean DI %
Q 1.1	MCQ	10	10	7.70	0.76	٠,١٩
Q 1.2	T/FQ	5	5	3.38	0.68	٠,١٢
Q 1.3	FSQ	5	5	3.36	0.58	٠,١٢
Q 2.1	EMQ	8	8	5.05	0.63	٠,٣٣
Q 2.2	RANQ	3	3+9	8	0.58	٠,٣٤
Q 2.3	FRSAQ	4	4+6	9.8	0.97	٠,٠٢
Q 3	PBQ	6	40	28.21	N/A	N/A

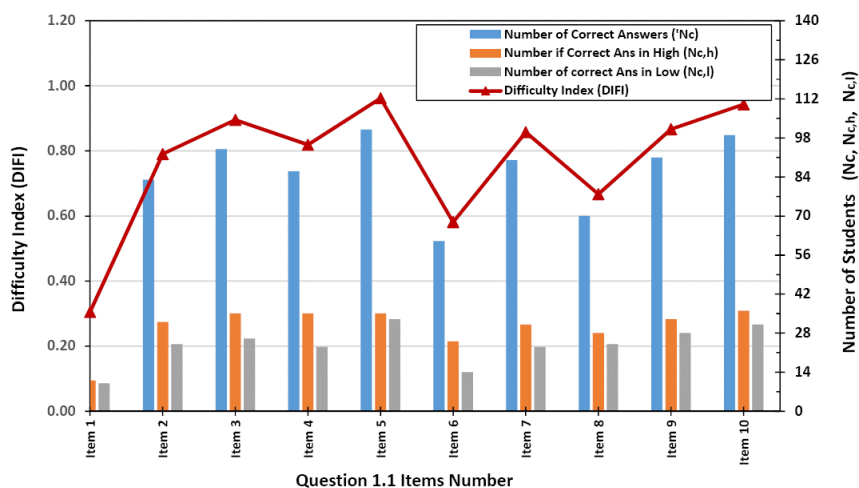
4 RESULTS AND DISCUSSION

This section gives the results of item analysis for written summative exam (WSE) performed in Aug 2020 by 105 of mainstream students of fourth level, in their final graduation stage during COVID-19 pandemic. The results of DIFI, DI, and DE are presented in this section. Then, the relationship between DIFI and DI is presented for the 35 MRQ Items, using both graph and map as commonly used presentation styles. At the end of this section, the classification for all 35 items of MRQs is demonstrated in tabulated form and grouped on pie charts based on Good, Fair, and Poor Classification.

4.1 Results of difficulty indices (DIFIs) for MRQs

Difficulty indices (DIFIs) for all items have been calculated and presented in Figure 4 upon the students results in summative examination for each individual question. For Q 1.1 the DIFI varies from 0.3 to nearly 0.9 as presented in Figure 4 (a). The DIFIs for Q 1.2 has a little margin than Q 1.1 and varies from 0.37 for item 16 to 0.82 for item 17. For Q 2.1 the difficulty index for the first four items is a little bit low and it increases for the rest four items to reach 0.98 at item 26. For Q 2.2 the DIFI was nearly the same for the last for items, low for the item 31 which reaches 0.2 and nearly equal for the first two items and records nearly 0.75. from difficulty index results it seems part of the items is easy items and part is too difficult and both needs to be modified. The rest is moderate questions which needs to be saved in the question bank required.

a) MCQs (Items 1-10),



b) T/FQs (Items 11-15), and FSQs (Items 16-20)

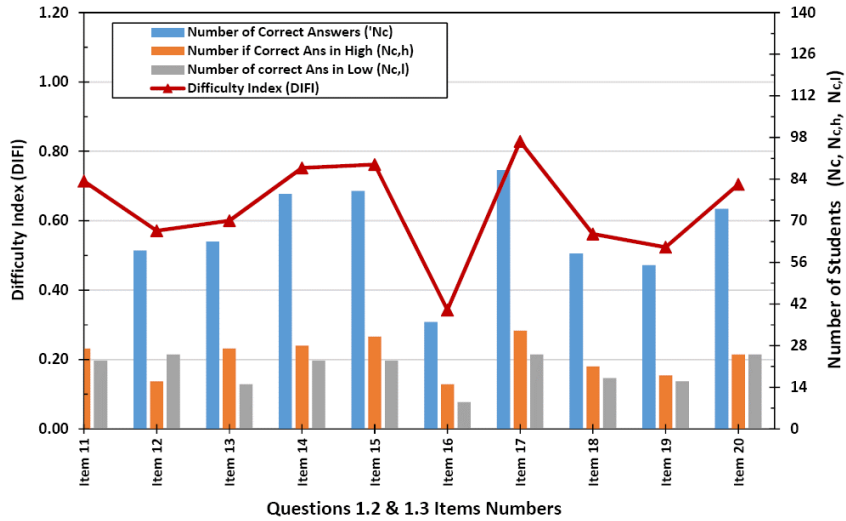
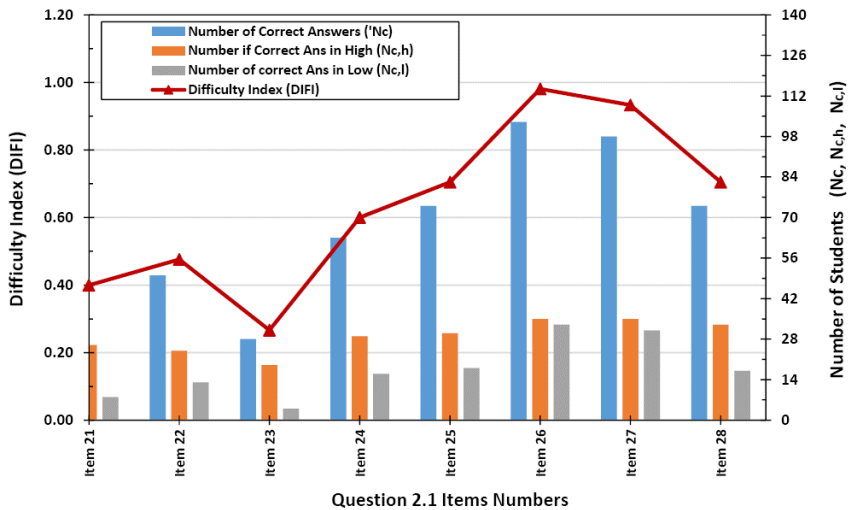


Figure 4: DIFI for questions Q.1 items: (a) MCQ items (1-10), (b) T/FQ (11-15) and FSQ items (16-20).

c) EMQs (Items 21-28)



d) RANQ (Items 29-31), and FRSAQs (Items 32-35).

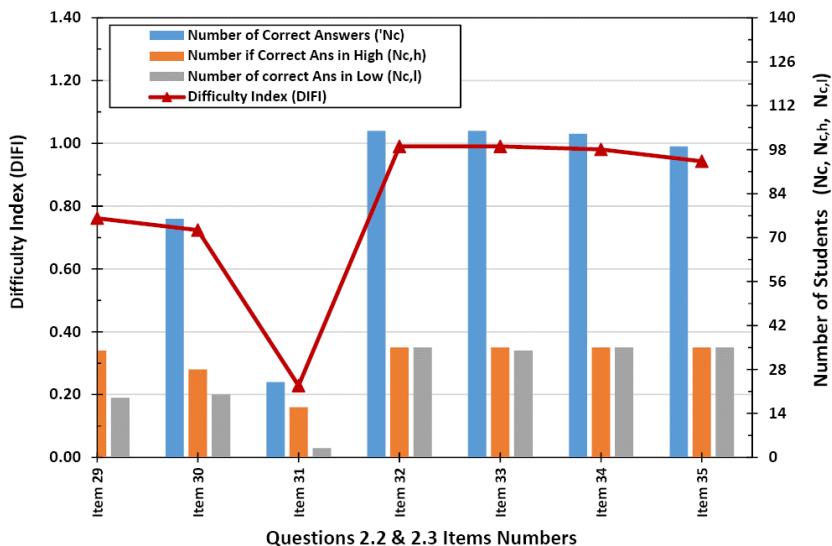
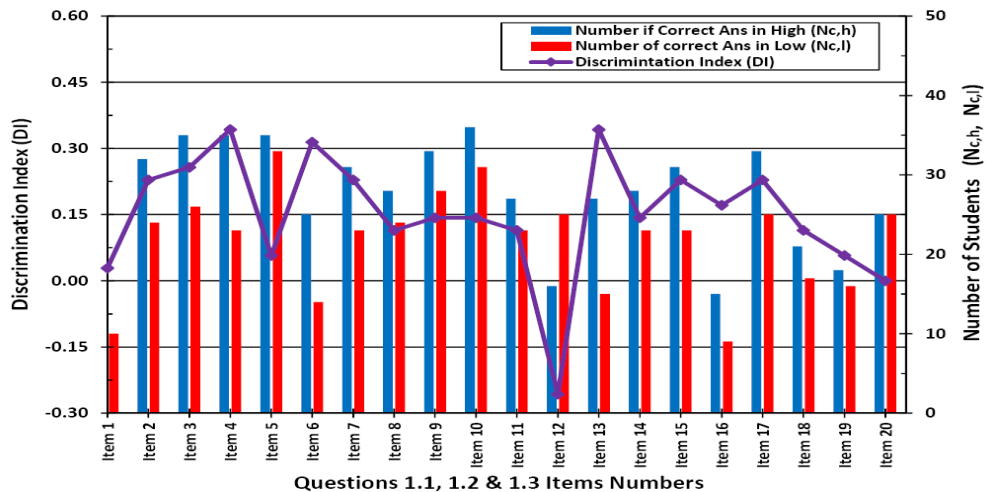


Figure 4 (Cont.): DIFI for questions Q.2 items (c) EMQ Items (21-28), (d) RANQ (29-31) and FRSAQ (32-35).

4.2 Results of discrimination indices (DIs) for MRQs

Results for discrimination index are presented in Figure 5 For individual questions. For Q.1. Items with discrimination index below 0.15 are 1, 5, 8, 9, 10, 11, 12, 14, 18, 19, 20 all these items are classified as poor items in discrimination between HAG and LAG. Meanwhile items 2, 3, 7, 14, 15, 16, 17 lied in the margin of 0.15-0.25 and classified as good items. Items 4, 6, 13 have DI greater than 0.25 and classified as excellent items in discrimination between HAG and LAG. For Q.2 items with DI below 0.15 are 26, 27, 32, 33, 34, 35 these items are classified as poor discrimination items. While item 30 came in the range 0.15-0.25 and classified as good item. Also, items 21, 22, 23, 24, 25, 28, 29, 31 records DI greater than 0.25 and classified as excellent items. All the results are presented in graphs in Figure 5.

a) Question 1 (1.1, 1.2, & 1.3) MRQs Items (1-20)



b) Question 2 (2.1, 2.2, & 2.3) MRQs Items (21-35)

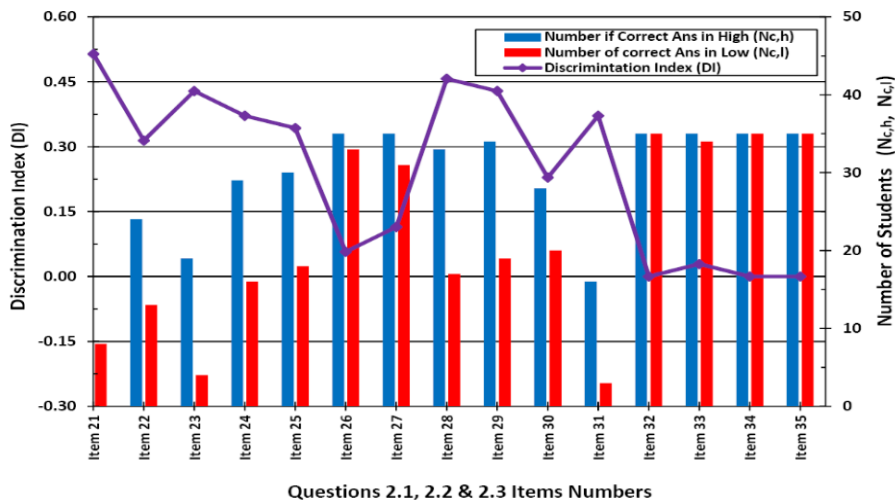


Figure 5: DI for Q.1 and Q.2 MRQ Items, (a) Q.1 Items (1-20), (b) Q.2 Items (21-35).

4.3 Results of distractor efficiency indices (DE) of MRQs

Total 35 MCQ with 105 distractors are analysed and the distractor efficiency is calculated for each item. If an Item has 3

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NFDs, the DE of that Item is 0%, or 2 NFDs, DE will be 33.3%, or one NFDs, DE will be 100% all the data and associated numbers and percentages are tabulated in Table 5.

Table 5: Distractor efficiency for MRQs, and NFD number and percentage for items.

Distractor analysis	Number	Percentage %
Number of items	35	-
Number of distractors	105	-
Non-functional distractors (NFDs)	56	53.33
Functional distractors (FDs)	49	46.66
Items with 0 NFD (DE=100%)	6	17.14
Items with 1 NFD (DE=66.6%)	10	28.57
Items with 2 NFD (DE=33.3%)	11	31.4
Items with 3 NFD (DE= 0%)	8	22.85

The number of functional distractors found 49 which is 46.66% of all distractors this means that the item analysis method enabled us to increase the functionality of items and make the exam items and distractors more efficient. Which leads finally to establish a question bank acts as an exam reservoir. The distractor efficiency of each item has been calculated according to the followed method. The results for distractor efficiency for each item are presented in the Figure 6. It is obvious that Q 2.3 items are problem-based questions. This what explains the zero-distractor efficiency of all items in this question. The problem-based questions have a numeric distractor and the result of problem solution leads to a certain number and the examiner should use distractors of numeric values reasonably away from the correct answer to bear in mind the round off made by students during solution. That is why most of the students goes to the correct answer after solution process. If an item has 3 NFDs, the DE of that Item is 0%, or 2 NFDs, DE will be 33.3%, or one NFD, DE

will be 66.6 % and if it has nil NFDs then DE will be 100%, as reported by suryadevara and bano (2018).

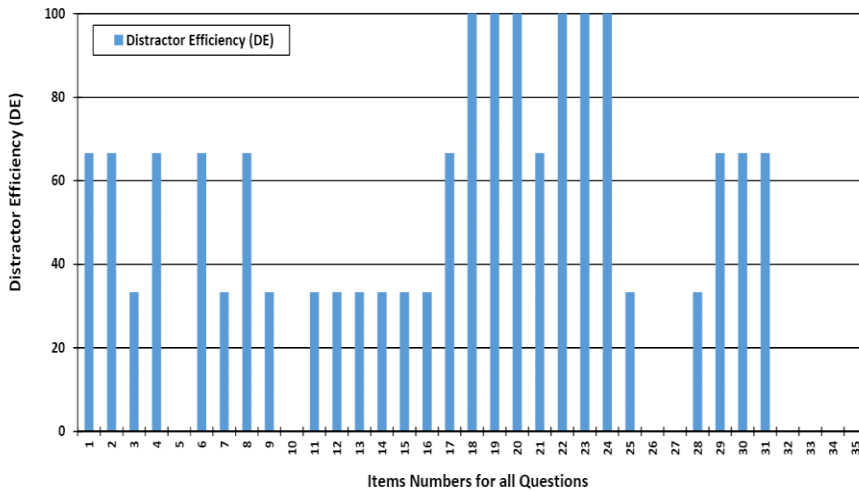


Figure 6: Distractor efficiency for MRQs items.

4.4 Relationship between DIFI and DI

The values of DIFI and DI for all items are grouped and plotted along all 35 MRQ items, as can be seen in Figure 7. Also, the relationship between DIFI (on x-axis) and DI (on Y-axis) is presented in Figure 8.

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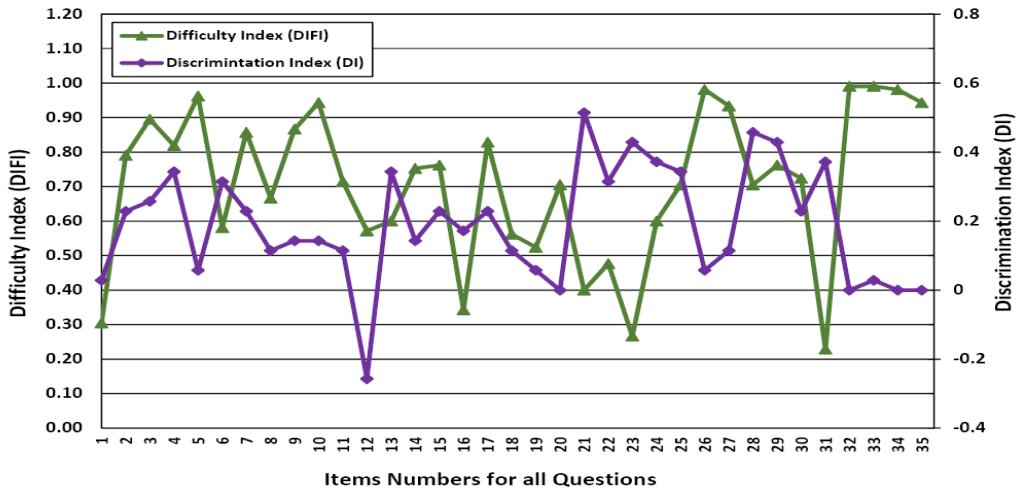


Figure 7: Values of DIFI & DI for all MRQ items (from 1 to 35).

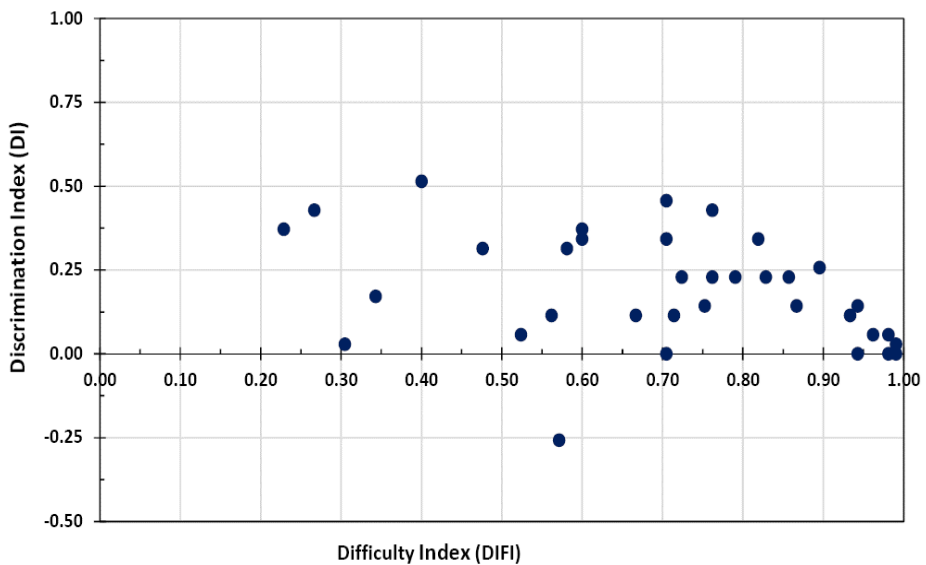


Figure 8: DIFI Vs. DI Relationship.

4.5 Classifications of question items

This section gives classification for items according to the adapted margins and the comparison parameter. Table 6 presents the classification of items in each question based on the classification according to their DIFI index. Figures 9, and 10 classify the Items on basis of DIFI, and on basis of DI, respectively. Figure 9 groups the items based on their level of difficulty, however, Figure 10 group the items based on their quality to measure the level of students in high group and low group.

Figure 9 presents the DIFI into six categories of difficulty which re very difficult (5%), difficult (8%), good (10%), excellent (28%), easy (15%), and very easy (34%). As can be seen from Figure 10 that the DI is classified into three groups Poor, good, nd Excellent. Their percentages recorded as 49% (Poor), 20% (Good) , and 31% (Excellent). Therefore, the recorded poor items should be carefully reviewed, replaced and modified before performing next academic year summative exam. Also, the items recorded with very easy DIFI of percentage (34%) should be reduced to not higher than 15%.

Table 6: Classification of Items according to DIFI, and DI.

Question No.	Question Type	No. of Items	DIFI CLASS	DI CLASS
Q 1.1	MCQ	10	(1) difficult (2) moderate (7) easy	(3) poor (4) good (3) excellent
Q 1.2	T/FQ	5	(0) difficult (2) moderate (3) easy	(2) poor (2) good (1) excellent
Q 1.3	FSQ	5	(0) difficult	(3) poor

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Question No.	Question Type	No. of Items	DIFI CLASS	DI CLASS
			(4) moderate (1) easy	(2) good (0) excellent
Q 2.1	EMQ	8	(1) difficult (5) moderate (2) easy	(2) poor (1) good (6) excellent
Q 2.2	RANQ	3	(1) difficult (0) moderate (2) easy	(0) poor (1) good (2) excellent
Q 2.3	FRSAQ	4	(0) difficult (0) moderate (4) easy	(4) poor (0) good (0) excellent

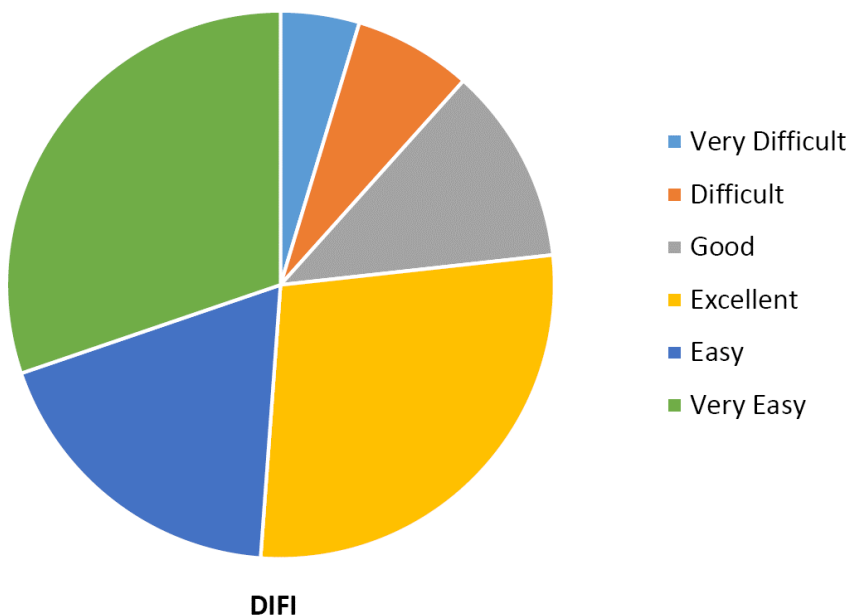


Figure 9: DIFI Classification for MRQs items according to Difficult/Easy levels.

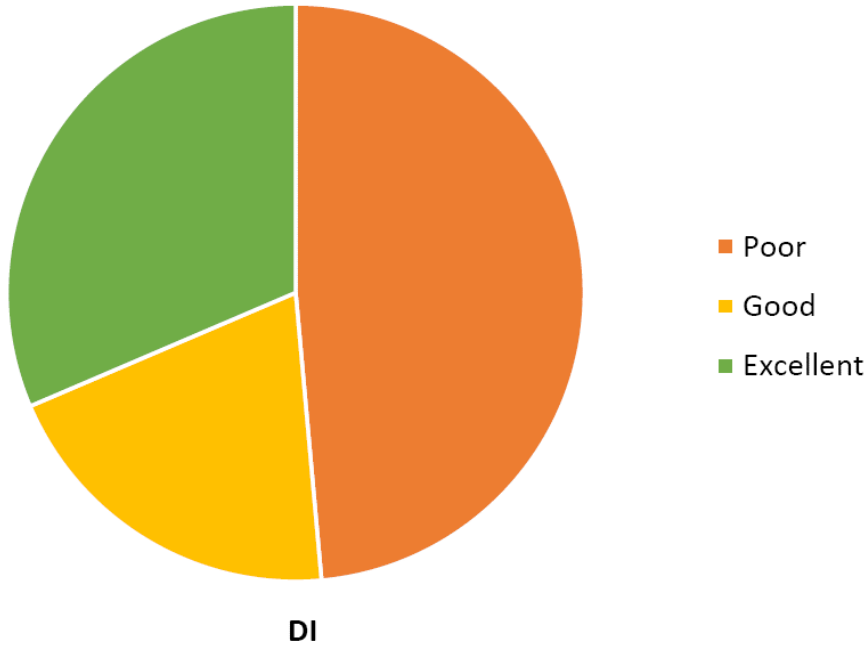


Figure 10: DI Classification for MRQs items according to Excellent/Poor basis.

5 CONCLUSIONS

In this paper, three main items can be concluded from the performed cross-sectional study for the summative Exams performed during COVID-19 Pandemic, based on the intended learning outcomes using hybrid educational method in mechanical engineering education. These three conclusion items can be sorted as following:

1- Hybrid education method can be successfully utilized to achieve all the ILOs of any mechanical engineering courses, using the most advanced online education software and channels.

2- The MRQs can be used besides PBQs to measure both HOTS and LOTs of ILOs, using a secured question banks for most of mechanical engineering courses, to be studied in faculty of engineering in Egyptian universities.

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3- Item analysis is an advanced evaluation method for MRQs, and PBQs to be used either in formative or summative exams for most of sciences such as engineering and medical sciences.

NOMENCLATURE

<i>DE</i>	Discrimination Index	(%)
<i>DI</i>	Discrimination Index	()
<i>DIFI</i>	Difficulty Index	(%)
<i>H</i>	Number of Correct Answer in High Grades Students	(student)
<i>L</i>	Number of Correct Answer in Low Grades Students	(student)
<i>M</i>	Number of students who have selected a specific distractor	(student)
<i>N</i>	Total number of students in both HAG and LAG	(student)
<i>N_C</i>	Number of Correct Answer Students	(student)
<i>N_{C,H}</i>	Number of Correct Answer in High Grades Students	(student)
<i>N_{C,L}</i>	Number of Correct Answer in Low Grades Students	(student)

Abbreviations

CHEP	Credit Hour Engineering Program	COVID	Corona Virus Disease
EMQ	Extended Match Question	FRSAQ	Free Response Short Answer Question
FSQ	Fill in Space Question	HAG	Higher Ability Group
ILO	Intended Learning Outcome	LAG	Lower Ability Group

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MCQ	Multi Choice Question	MRQ	Multi Response Question
N/A	Not Available	N/R	Not Requested
OBE	Open Book Exam	PBQ	Problem Based Question
RANQ	Ranking Question	T/FQ	True/ False Question
WSE	Written Summative Exam		

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