Penerbit Akademia Baru

International Journal of Advanced Research in Future Ready Learning and Education

https://www.akademiabaru.com/submit/index.php/frle/index

ISSN: 2462 - 1951

Contextual Teaching of Engineering Mathematics to Improve Levels of Accuracy and Confidence in Covid-19 Knowledge

Ahmad Salahuddin Mohd Harithuddin[1,*], Adi Azriff Basri[1]

[1] Department of Aerospace Engineering, University Putra Malaysia, Serdang, Selangor, Malaysia

ABSTRACT

Since late March 2020, reports about the COVID-19 pandemic flooded the daily news. However, most of the epidemiological terms of used in the mass media were new to most people other than the medical circles. Engineering students, though not included in the circles, must be equipped with the ability to apply reasoning informed by knowledge to assess public health issues like this from the context of "The Engineer and Society". This paper reports a way of teaching the concepts of calculus using the compartmental modelling - the SIR (Susceptible, Infectious, and Removed) model - of which some epidemiological terms are used in the media. A pre-test set of questions is given to students before conducting a series of online calculus lessons, followed by a post-test after the students submit their technical reports. Student's feedback on the contextual learning of calculus is collected and discussed. The results demonstrate that the engineering student's prior knowledge on the epidemiological terms presented in the media are low but gained significant increment after the specially-designed lessons. Open feedback from students indicates that in general are appreciative of the effort of applying real-world context in a calculus course. Interestingly also, due to it not being an expected result, students are more appreciative of the fact that they learn how to use spreadsheet programs to model the pandemic.

Keywords:
Covid-19; online learning; learning management system; movement control order

Received: 15 January 2025	Revised: 10 February 2025	Accepted: 20 February 2025	Published: 20 March 2025

1. Introduction

On 30 January 2020, the World Health Organization (WHO) declared the outbreak as a public health emergency of international concern. In addition, on 11 March 2020, the WHO announced the COVID-19 outbreak as a "pandemic." More than 84.5 million cases with more than 1.8 million deaths due to COVID-19 were con-firmed as of 01 January 2021. Many countries have implemented large-scale public health and social measures in response to COVID-19, including restrictions on movement, closure of schools and businesses, geographic quarantine, and international travel restrictions.

At our faculty of engineering, we have identified a problem with our first-year students: they lack the awareness and knowledge in assessing the current societal and health issues, namely the COVID-19 pandemic. This conjecture is supported a study on the public knowledge towards COVID-19 in [1]

* *Corresponding author.*
E-mail address: a_salahuddin@upm.edu.my

https://doi.org/10.37934/frle.38.1.2336

reported that Malaysians between 18-29 years of age scored the lowest in knowledge compared to the older groups. This is despite the wide coverage in mass and social media, and the constant public discussion on policy responses to the global pandemic.

In the early days of the pandemic, information on the COVID-19 - how the disease spread and how to control it - was rapidly circulated. The news on COVID-19 quickly evolved - unfamiliar scientific jargons and terms are increasingly being used and reused without much explanation to them. Technical terms - flattening the curve, R-naught, incubation period, social distancing - are thrown around to indicate the current situation of the pandemic but without much explanation behind them. The complex charts and graphs used to convey information - like the logarithmic scale graph for example - might be misinterpreted by an unfamiliar public [2] and even specialized scientists [3].

Health education programs and awareness campaigns that include correct and relevant information can improve people's knowledge on the pandemic. This, in turn, can help improve the societal attitude towards accepting health authorities' efforts to change people's habits. There are a number of online initiatives aimed at educating the public on the meaning of the technical jargons used in the media by publishing COVID-19 related vocabularies [4-6]. The Learning Network (https://www.nytimes.com/spotlight/learning-network-coronavirus) is another good resource initiated to help public education on the pandemic, among other topics, by providing materials to teachers and suggesting activities to students.

But how does this relate academically to engineering? What is the role of a student of engineering in a field which is seemingly more suitable for health workers? One of the basic building blocks of an engineering pro-gram is conceptually-based mathematics that supports analysis and modelling applicable to the discipline. The Washington Accord [7] lists a set of twelve graduate attributes - elements that indicate an engineering student's ability to gain competence to practice at the appropriate level after graduation.

There are at least two that are closely relevant here. One is the ability of an engineer to comprehend and play a role in society: *"Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems"*. Another is the ability to communicate effectively with society at large: *"Communicate effectively on complex engineering activities with the engineering community and with society at large".*

The term 'complex engineering activities' as indicated in the Engineering Programme Accreditation Standard 2020 [8] includes activities that "*[r]equire resolution of significant problems arising from interactions between wide ranging or conflicting technical, engineering or other issues*" and "*[h]ave significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation*". In the current pandemic context, communication here may involve efforts of explaining public health data and decisions from the perspectives of applied analysis, which defines the core of engineering mathematics [9]. The aim here therefore is to apply conceptual knowledge of engineering mathematics to assess the issues of the now i.e., the COVID-19 pandemic, and build skills in effective science communication [10].

Calculus is one of the foundational subjects in an engineering curriculum. As it concerns mathematical methods and techniques to solve problems typical to engineering, it is usually taught in the first few semesters of an undergraduate engineering program to support analysis and modelling in courses. It is expected that the students of an engineering programme to be able to apply knowledge of mathematics to the solution of complex engineering problems [7,8].

The pandemic offers a unique opportunity to improve a long-standing issue in calculus instruction in our engineering faculty. Introductory mathematics taught in universities typically focuses on facts, formulas, procedures and manipulation skills - a concept that is not far from rote learning. Perhaps this is a continuation from the style of teaching from secondary education as it was aimed at preparing students for the national examinations [11].

Tall [12] described (as cited in Gravemeijer and Doorman's paper on Realistic Mathematical Education [13]) the weakness of the traditional setup of how calculus is taught: a complex mathematical topic is broken down into smaller, simpler parts that can be arranged into a mathematically logical sequence. For example, to teach differential calculus, one would traditionally begin with the introduction of set theory, functions, limits, derivative, and differentiation respectively. The problem here, paraphrasing Tall, is that the instructor sees the smaller parts as components of the whole, while students see them as separated, unhinged from the bigger picture. For example, students might see the limit 'part' as a standalone and separated concept not needed for doing the 'product rule'. Tall suggested instructors find situations to use as context to start off a more insightful instructional sequence.

The call for contextual teaching of mathematics in engineering is not unfamiliar in the engineering education circles. This is, in fact, in line with the recommendation from the Engineering Accreditation Council of Malaysia, which oversees the assessment of engineering programmes in the country, that mathematics courses be *"...studied to a level necessary to the engineering courses ...with a bias towards application. Wherever practicable, it is preferred that mathematics, statistics and computing are taught in the context of their application to engineering problems*" [8]. This news about the pandemic in the media, the revision of calculus concepts and the SIR model are central to our concept of contextual teaching in this study.

2. Application Design and Implementation

The challenge for engineering educators is then to synergistically incorporate public health education and scientific communication into our existing courses instead of creating an entirely new course. ECC3011 Engineering Mathematics I is the first engineering mathematics course in the engineering degree program at the Faculty of Engineering, Universiti Putra Malaysia. The course focuses mainly on calculus with other topics concerning engineering mathematics like linear algebra, real and complex analysis included. It is one of the three major courses for engineering mathematics for the bachelor of aerospace engineering program with the other two being Engineering Mathematics II, which deals with multivariable calculus and differential equations, and Engineering Statistics, which concerns probability and statistics. Consistently, every semester, about 300 students take Engineering Mathematics I in the first semester of their respective engineering programs. This study is limited to participants from the bachelor of aerospace engineering program of the First Semester 2020/2021 (started in October 2020 - February 2021) which comprises 40 students.

A learning outcome as defined by Adam [14] is "a written statement of what the successful student/learner is expected to be able to do at the end of a period of learning". At the end of the ECC3011 Engineering Mathematics I course, students should be able to:

i) solve mathematical problems by using tools and concepts of engineering mathematics like functions, complex numbers, matrices, sequences and series, differentiation, and integration.
ii) analyze problems involving mathematical concepts like functions, complex numbers, matrices, sequences and series, differentiation, and integration to solve engineering problems.
iii) explain mathematical problem solving related to engineering.

The learning outcomes focus on the achievement of the students rather than the intentions of the instructor. For the purpose of this study, apart from outlining the learning outcomes, it is also important to indicate the intention of the learning module. It is two-fold: (1) to create a contextualized learning experience that shows the direct application of engineering mathematics in real life situations; and (2) to increase awareness, knowledge, concern, and preparedness in facing the COVID-19 pandemic as members of society. The objective of this study therefore is to assess their improvement of understanding of both the concepts of engineering mathematics, particularly calculus, and epidemiological terms and concepts related to the pandemic.

2.1 Learning Design

The first seven weeks of instructions were mainly focused on solving mathematical problems - typically the back-of-the-textbook type of problems - using tools and concepts of engineering mathematics (learning outcome #1). By this time, students had been exposed with the concepts of derivatives and antiderivatives. At the end of the seventh week, a short primer on building the differential equations that make up the Susceptible, Infectious, and Removed (SIR) model - a basic compartmental epidemic model for infectious disease transmission - was given to the students. This model was proposed by Kermack and McKendrick [15] in 1927, and it was used as a basic model for epidemics. Though the SIR model is limited in the sense that it could not efficiently simulate the current pandemic situation, it is found that it is very helpful in contextualizing some of the calculus concepts and techniques (here, the aphorism from Box [16] is invoked: "all models are wrong, but some are useful"). The primer also contains instructions on applying the mathematical model in spreadsheets - numerically integrating the differential equations and visualizing functions through graphs. It is divided into five sections: the *Introduction* introduces the concept of mathematical modelling and the building blocks of the SIR model; the second section, called *Thinking About Modelling*, continues the discussion by explaining about functions, rate of change, applications of limits in finding the derivative of function and ends with a set of three differential equations that is the SIR model; the next section, called *Understanding About Models* discusses about the meanings of in context of a disease outbreak e.g. the meaning of infection rates, recovery rates, and how to understand them. The fourth section *Getting the Numbers* focuses on applying the developed set of differential equations into spreadsheets in order to numerically integrate them and produce graphs for visualization. The primer ends with the *Tasks* section describing the tasks that the student should do in this learning module. The primer is written in a conversational way as an effort to move closer to a public discourse rather than a purely technical communication. The language of calculus (e.g., ‘functions’, ‘limits’, ‘rate of change’) were still liberally used together with the frequently-mentioned, pandemic-related terms (‘infection’, ‘flattening the curve’, ‘contacts per day’).

In this module, students were asked to write a technical paper. The content of the paper should have:

i) Title - where students are asked to craft a title that catches the reader's attention.
ii) Abstract - a single paragraph that summarizes the article and its major contributions. It contains a general introduction to the topic, outlines the major results, and summarizes the conclusions.
iii) Introduction - that starts with an attention-getting broad statement that establishes a general topic for the article. It should brief the student’s current state of knowledge on calculus and how is this applied to the current problem. It should end with a statement of the specific contribution of the article and the overall organization of the article.
iv) Methodology - that describes briefly but succinctly the calculus techniques (e.g., function, rate of change, Euler's integration method) used to obtain the mathematical model and the results.

v) Results - that shows at least one simulation produced from the SIR model that the students have developed.

vi) Discussion - Here the students were asked to discuss the answer to these questions.

a. Based on your simulation of the SIR model, what do you think "flatten the curve" means? Why is it important? Show an example of a "flattened curve" model and a model where the curve is "not flattened".

b. The basic reproduction number is denoted as R_0. What does it mean? What will happen when R_0>1. Why do we need the value of R_0 to be below 1?

c. How infection control measures like social distancing and wearing masks can affect the dynamics of COVID-19 outbreak. You may discuss how these measures affect the parameter p and q and how this, in turn, affects the infection rate.

vii) Conclusion - tell your readers briefly how calculus is being used in creating a mathematical model to understand the spread of a disease.

After the submission of the report, a self-assessment survey is conducted. Students were given two sets of glossaries containing terms related to engineering mathematics and terms that are usually found in the discourse of the COVID-19 pandemic [5,17] as shown in Table 1. The survey asked students to self-assess their pre-instruction and post-instruction knowledge on a number of terms and concepts. An example of a pair of questions in the survey for calculus terms and definition is "*BEFORE doing the assignment, I can explain the following concepts of calculus to others with confidence. [rate of change]*" and "*AFTER doing the assignment, I can explain the following concepts of calculus to others with confidence. [rate of change]*". In essence, the questions are posed for students to self-assess how well they can explain each of the terms in the first column of Table 1. For the mathematical terms related to calculus, a 5-point Likert scale was used to indicate students' own level of understanding: from 1-Strongly Disagree to 5-Strongly Agree.

Similarly, the students were asked to gauge their informed knowledge on the technical terms related to the COVID-19 pandemic as shown in the second column of Table 1. For the epidemiological terms, a 4-point Likert scale was used to measure informed knowledge on a list of 22 epidemiological terms: 1-Misinformed, 2-Uninformed, 3-Partially Informed, and 4-Well Informed. The intention is to map out the results later using the 2-by-2 grid map in Figure 1. The map shows four types of informedness - *misinformed, uninformed, partially informed, and well-informed* - arranged in a two-dimensional space. This is an idea proposed by Lee and Matsuo [18] to measure political knowledge; here, the same Level of Accuracy vs Level of Confidence map is applied to map the students' COVID-19 knowledge.

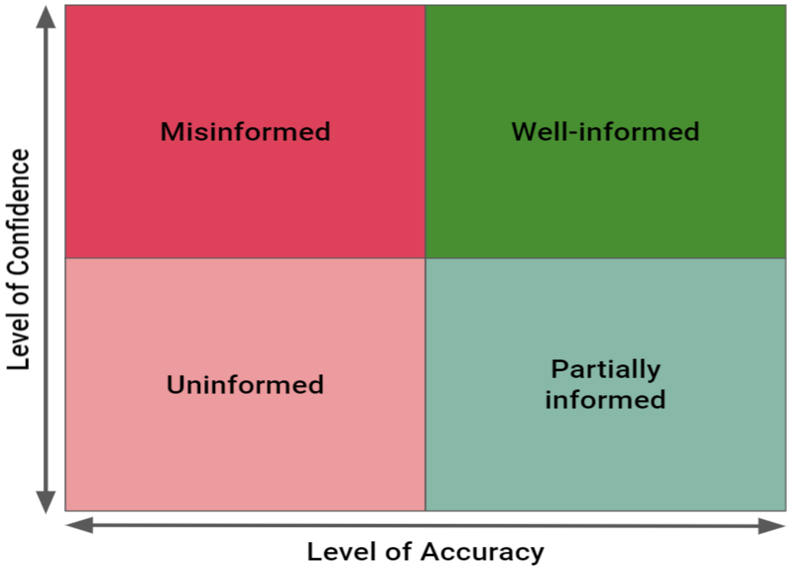

Fig. 1. Mapping out COVID-19 knowledge based on Level of Accuracy (measuring the factual knowledge of COVID-19 jargons), and Level of Confidence (how confident students are about their knowledge on COVID-19 jargons)

3. Methodology

Initial pre-test/post-rest results shows a significant increment after the activity. A summary of the still ongoing study is depicted in Table 1. It has been shown from the feedback of the students that while our initial objectives of teaching concepts of calculus and familiarizing students with COVID-19 jargons are achieved, the students also learned new skills.

Table 1
A glossary of calculus and epidemiological terms used in COVID-19 pandemic reporting in the mass media

Calculus Terms	COVID-19 Terms
antiderivative	basic reproduction number
average	close contact
change with respect to time	compartmental model
constant	epidemic
delta	epidemiology
derivative	flattening the curve
differential equation	immunity
function of time	incubation period
initial condition	infected
integration	infectious
mathematical model	infection rate
numerical integration	outbreak
parameters	pandemic
rate of change	quarantine
ratio	recovery rate
variable	social distancing
	susceptible
	transmission

3.1 Compartmental Model for COVID-19 Transmission

To model COVID-19 transmission using the SIR model, we let $N(t)$ be the total human population size in the community at time t. This population is divided into three mutually-exclusive compartments: We let $I(t)$ be number of individuals who are infected by the disease and can spread the disease; $R(t)$ to be the number of individuals who has recovered from the disease, or removed, and therefore cannot catch a disease or spread it; and $S(t)$ to be the number of susceptible individuals, that is people who have not yet contracted the disease but can catch the disease.

Several simplifying assumptions are made about the rates of change of the dependent variables: The total population number N is constant; no human demographic processes are involved e.g., migration, new births or deaths due to causes other than the disease. Any individual in the population is either be a susceptible, an infected, or a removed, i.e. $N(t) = S(t) + I(t) + R(t) = constant$ (visualized in the primer as in Figure 2). It is also assumed that the population is large and the individuals in the population are mixing around, i.e., a person in one group is in contact with individuals in other groups every day. The only way an individual can leave the susceptible S group is to become infected, I; and the only way one can leave the infected I group is to recover/be removed from the disease, hence immune and cannot spread the disease (R group).

One of the activities in the module is to develop the differential equations of the SIR model. Visualization such as shown in Figure 3 was provided for students to gain intuitions necessary to provide insights and induce students to recognize patterns and complex relationships among concepts [19].

The rates of change of the three populations are governed by the following system of differential equations in Eq. (1);

$$\begin{aligned} \frac{dS(t)}{dt} &= -\beta S(t)I(t) \\ \frac{dI(t)}{dx} &= \beta S(t)I(t) - \gamma I(t) \\ \frac{dR(t)}{dt} &= \gamma I(t) \end{aligned} \tag{1}$$

where β and γ denote the infection rate and the recovery rate, respectively. The infection rate β is a product of transmissibility q (where $q = 1$ denotes a 100% transmissibility upon contact and $q = 0$ means the disease is non-transmissible), and *p* the average number of contacts between the susceptible and infected individuals in Eq. (2).

$$\beta = qp \tag{2}$$

Let r be the number of days an infected individual person can remain infectious (in other words, number of infectious day), then the recovery rate γ in Eq. (3) can be calculated as

$$\gamma = 1/r \tag{3}$$

These three measures - number of infectious days r, number of contacts between susceptible and infected per day p, and the transmissibility of the disease q - were introduced to students with the intention of building a closer connection between 'the math' and the action of the population like incubation period, social distancing, and contagiousness of the disease. This is instead of spoon-feeding values β and γ for students to work on without contextualizing.

The final activity was to numerically integrate the differential equation using the Euler's integration method. The numerical integration was done using spreadsheets as a way to include all four types of mathematical representation: symbolic, graphics, numeric and verbal (instruction posted online) in the teaching approach as shown in Figure 2. This is an idea that was borrowed heavily from the "Rule of Four" advocated by Hughes-Hallet *et al.,* [20] among others (as quoted from Knill [21]) that combined with awareness of some of its limitations [22].

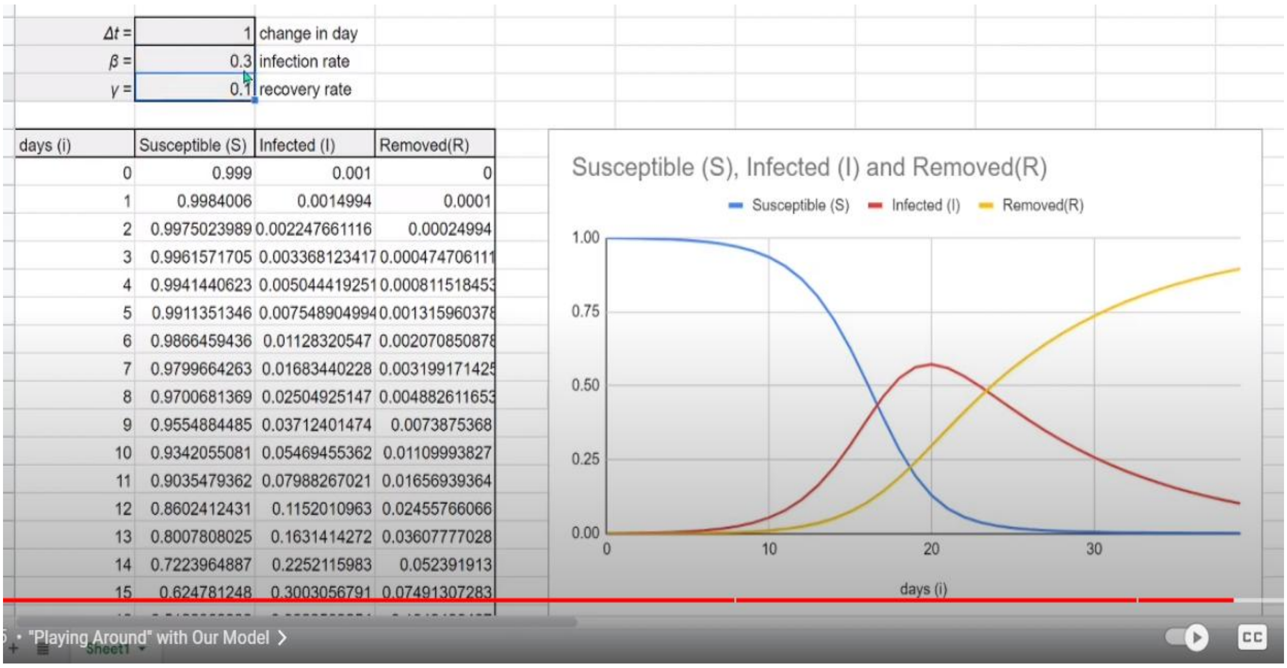

Fig. 2. Numerical integration using spreadsheets to make connections between symbolic, numeric and graphical representations of a problem. Taken from authors' video instruction. (Source: SIR Model: Applying Euler Integration Method in Spreadsheet https://youtu.be/hYrQChlz5zw)

3.2 Instructions

All of the teaching and learning activities related to this are done online due to the Movement Control Order that was imposed on all Malaysian citizens during the pandemic. Video conferencing was via the Microsoft Team applications. An online discussion forum was set up for class discussion using the same application. A two-hour synchronous video conferencing session was conducted explaining the assessment tasks and the content of the short primer prepared for the students. The session was recorded for later access by the students. An additional tutorial video on how to use spreadsheets to model the differential equations was published on YouTube for students to learn outside class hours.

Students were given four weeks to work on the tasks. Students were encouraged to learn together with their peers online, but the final deliverable was set to be assessed individually. The assessment rubric was shared with the students to set expectations, guide inquiry, and promote self-evaluation and guide inquiry tasks. One-to-one lecturer-student communication was done mostly via Whatsapp. This instant messaging app was preferred by students to get feedback and advice; perhaps due to the app's suitability for quick personal communication (chat-based) and its file-sharing capability. The set-up online forum on Microsoft Team was rarely used but it was apparent - from personal communication with the students - that they used Whatsapp for peer-to-peer communication (due to its usage popularity in Malaysia).

4. Findings

Statistical analysis of the pre- and post-instruction average scores for a group of 40 aerospace engineering students on the self-assessment of calculus terms (minimum score =1 and maximum score = 5) shows a significant improvement. The mean pre-instruction and post-instruction scores were 3.15 and 4.24 with a mean increment of 1.08 (The value of t is 8.79. The result is significant at $p < .05$). One student, however, scored -0.25 less than the pre-instruction module. The instruction was effective in that the students perceived that they understood more than they did about the 16 calculus terms at the beginning of the instruction.

For the informed knowledge of COVID-19 technical terms, the pre-instruction and post-instruction responses from students are visualized in Figure 3. Each cell in the Figure 3 indicates each individual student's response, represented by the columns, to each of the questions in the survey. Responses are categorized to '*well-informed*' (high accuracy, high confidence), '*partially-informed*' (high accuracy but low confidence), '*uninformed*' (low accuracy and low confidence), and '*misinformed*' (low accuracy but high confidence). In general, there is an overall shift towards the '*well-informed*' category.

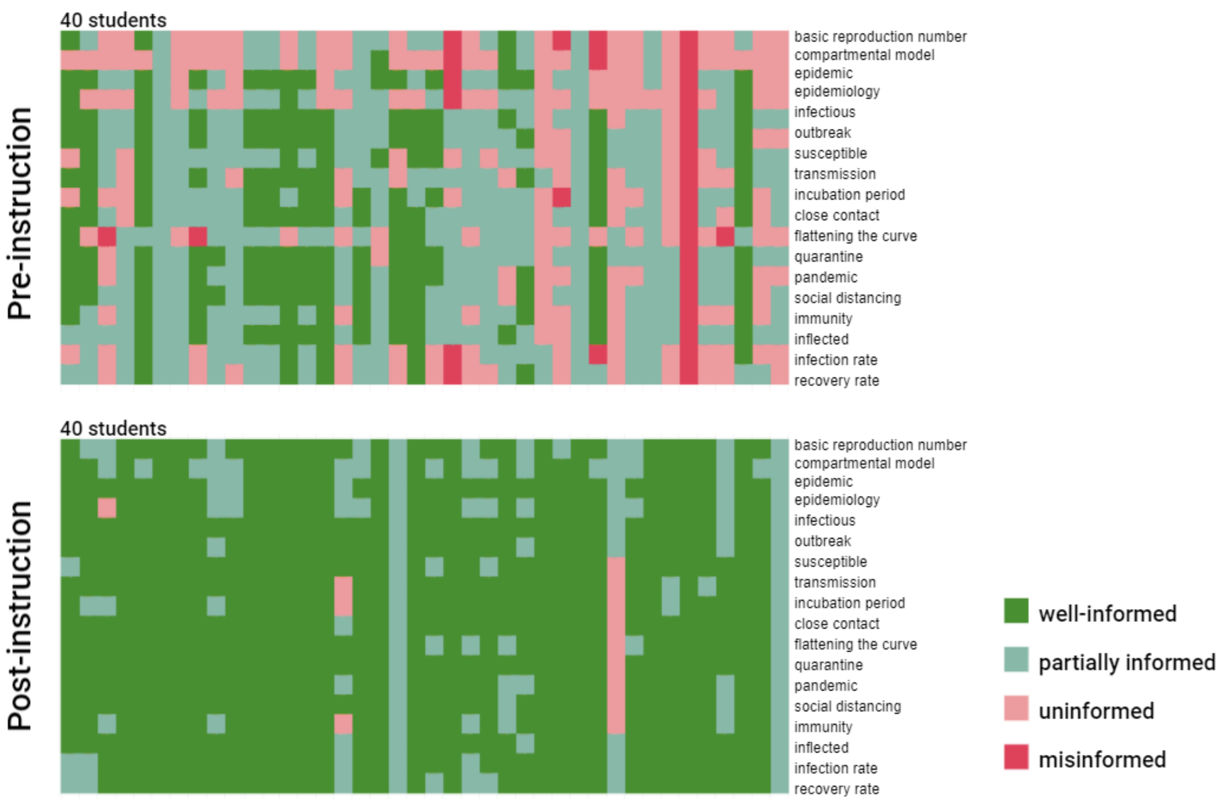

Fig. 3. Response of 40 students on their self-assessed knowledge of a number of COVID-19 terms

The shift can be illustrated more clearly using the 2-by-2 grid maps. The way the map is plotted is the following: if more students picked high-accuracy options - i.e., well-informed and partially informed - to indicate their informedness of a term presented to them, the data point gravitates to the right in the horizontal direction. Similarly, if more students picked high-confidence options for a word - i.e., misinformed and well informed - the data point is pushed higher in the vertical direction.

Therefore, the position of a data point on the map suggests the cate-gory of COVID-19 knowledge of the student on average whether they are misinformed, uninformed, partially-informed, or well-informed.

The average score for every question "*BEFORE the assignment, how informed are you on the following concepts of COVID-19 as an epidemic? (COVID-19 terms)*" is plotted in Figure 4. Each mark on the map rep-resents a term in the glossary given to the students. It is apparent that, before the instruction started, the students generally did not feel confident of their knowledge on the jargons of the pandemic. Notably, students in general are not familiar (lack factual knowledge) on the terms '*compartmental model*', '*basic reproduction number*', and '*epidemiology*'. Next to these lowest-scoring terms, the often-used '*flattening the curve*' also scored 0.1 on the level of accuracy and -0.65 on the level of confidence (the scoring range for each dimension is normalized from -1 to 1) Relatively, on average, students indicate high factual knowledge on terms like '*quarantine*', '*social distancing*', '*infected*' and '*infectious*'.

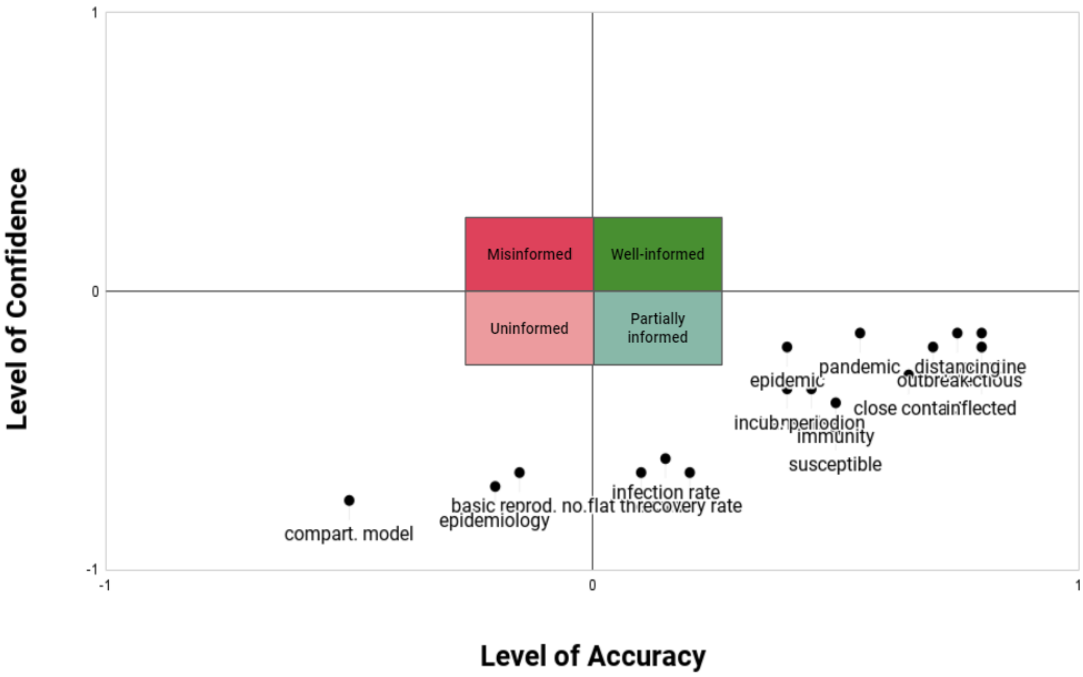

Fig. 4. Mapping of level of accuracy vs. level of confidence of student's knowledge of covid-19 terminologies before the assignment

The summary of the post-instruction scores is plotted in Figure 5. All students recorded "*well-informed*" for each of the 18 terms in the glossary. A 1 score on the level of accuracy means that none of the students were misinformed or uninformed about any of the term. The three lowest-scoring terms - '*compartmental model*', '*basic reproduction number*', and '*epidemiology*'- made a huge shift a 1 on the accuracy level, however, students also felt less confident on those compared to other terms. 'Flattening the curve' made a huge jump to 0.95 in accuracy and 0.65 in confidence. In general, by the end of the instruction and their report submission, students are well-informed on all the jargons listed in the glossary in Table 1.

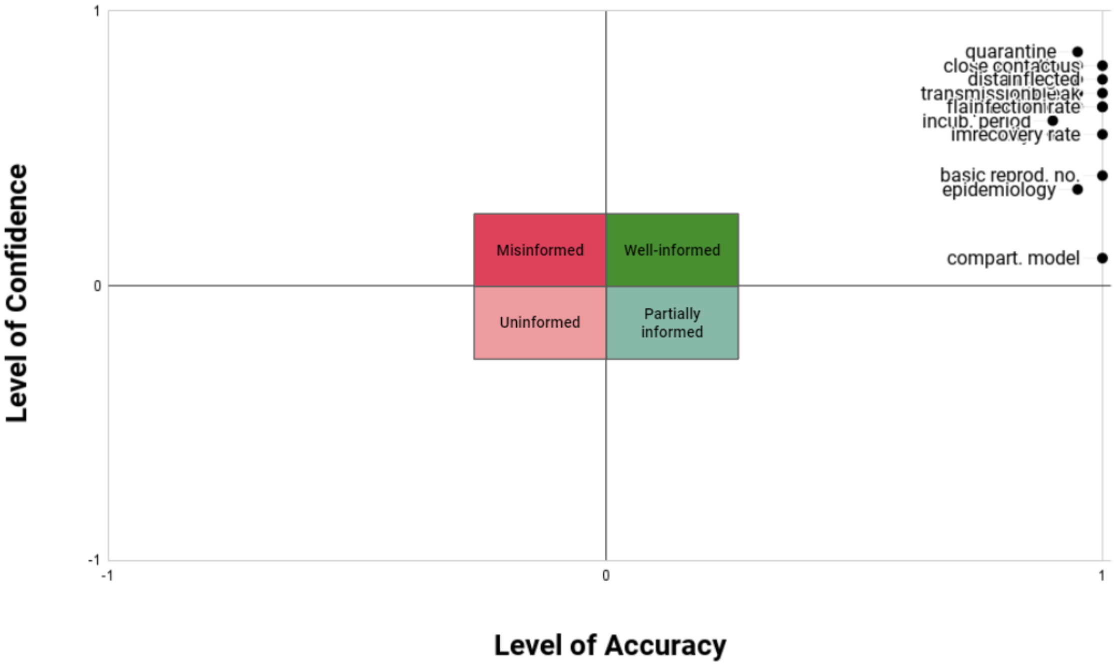

Fig. 5. Mapping of level of accuracy vs. level of confidence of student's knowledge of covid-19 terminologies after the assignment

Several selected report snippets are shown here to show examples of how students could explain a public health crisis using the language of mathematics. This is an example of how understanding the concept of the infection rate β can translate into real-life situations and explain some public health policies.

"...the society should do something to reduce the infection rate, β. Basically this can be accomplished by social distancing through containment, wearing masks and mitigation efforts like Movement Control Order (MCO). By this way the transmissibility, q can be reduced. When people obey the social distancing rule, the number of contacts per day, p can be reduced."

The quote shown here is taken from one of the submitted reports. Here is an example of a student explaining the concept of the reproduction number R-naught.

"The amount of people that can be infected by an infected person is basic reproduction number R0, or also known as reproduction rate denoted as R0=$\beta\gamma$. If the reproduction rate R0>1, manifests that there is no protective measure taken which will lead to a non-flattened curve and cause healthcare system failures as stated before where a sudden spike occurs in a short period of time with an overwhelming number of cases which will passing the limit of the healthcare capacities... Thus, it is significant to maintain R0>1 where the outbreak of epidemic or pandemic will be within the grasp and avoid a worse-case scenario where death is stacked."

In this example a student explained the concept of '*flattening the curve*' using a figure of which they generated using a spreadsheet and hypothetical numbers. This is also an example of a demonstration of an authentic understanding of the term. Though the technical writing aspect can be improved, this snippet in a way demonstrates the student's genuine knowledge of the term.

> *"Based on Figure 2, we can see that the maximum number of infected populations is on day 25 as over 60% of the population has been infected by COVID-19. This would mean that the hospital would receive 60% or 30 000 population of infected people in that time. This would pose a question, would there be enough hospital beds for these infected people? Would there be enough re-sources like medical supplies, staff, or ventilator to help these infected people? Can the healthcare system handle this many infected people at the same time? This is what "flatten the curve" means, which is slowing the spread of the epidemic so that the maximum number of people who require care at a time is reduced and its capacity is not exceeded by the health care sys-tem. When a lot of people get sick at the same time, the capacity of the healthcare system will get overloaded and can get worse as the health worker can get sick themselves."*

In one example, a student demonstrated a deeper understanding of mathematical modeling with a recognition of its limits. The student narrates on how the visualization made understanding better ("*easy to grasp*").

> "*Calculus is one major application that is used to predict the dynamic of a disease outbreak. The models can provide useful predictions and data which also can be made as a benchmark in fighting the disease. In this model, SIR model is constructed using calculus fundamentals like rate of change to trace the change of number in potential infected individuals to recovered patients. This model provides a more theoretical approach in predicting the outbreak. The parameters are easy to control and the graph is easy to grasp and adjustment can be made easily. Governments can use SIR models to effectively plan strategies to flatten the curve as there is a foresight of the outbreak. This model however only limits to a simple study as the parameter used not representing the population behavior, complexity in real-life and many assumptions is taken to make the model works."*

We identified limitations in our study in terms of the measurement understanding based on self-assessment, the ambiguity of the terms used in the questionnaire, and the glossaries provided.

i) The self-assessment by students might not accurately measure a student's true understanding of the presented technical terms. To measure knowledge about COVID-19, a modification to the study instrument presented in Azlan *et al.,* [1] which was adapted from previous research by Zhong *et al.,* [23]. The modified instrument can include transmission routes and prevention and control of COVID-19 and put in context with the mathematics instruction. To measure understanding of the related calculus concepts, a pre- and post-quiz in terms of objective test-items can serve the purpose.

ii) The initial plan was to map the student's response of their self-assessed informed knowledge of COVID-19 in a map shown in Figure 1. However, due to the formatting of the questionnaire in Google Form, this mapping is not apparent. The answer choices (1-*Misinformed*, 2-*Uninformed*, 3-*Partially Informed*, and 4-*Well Informed*) were arranged in series, following the norm of a Likert-scale type of rating. Though no student complained that it was confusing, a clearer diagram can certainly help surveyed students answering the questions with more surety.

iii) The COVID-19 glossaries presented on its own might have left some actual context in the news. Additional reference to current online articles about the pandemic may be more meaningful and provide more context.

5. Conclusion

The aim of this learning design is to tackle two problems: (1) improving the instruction and assessment of calculus, moving from rote-learning from their secondary school experience to more “real”, context-based problems; and (2) improving younger generations of engineering students’ knowledge on the COVID-19. A way to tailor such learning design is to provide mathematical instructions together with an authentic context that is the COVID-19 pandemic. The survey has seen a significant improvement on their confidence of their knowledge on calculus terms and concepts and shifted their knowledge of COVID-19 to a higher level of accuracy and confidence. Though some may argue that the context is not a pure engineering problem, we see that this is extremely relevant in building the attributes of a graduate engineering in that they apply mathematical analysis and reasoning informed by contextual knowledge to assess an issue in public health. With the constant stream of information from the mass and social media regarding the COVID-19 pandemic, it is important also to educate engineering students on how to process information in the time of crisis and, in turn, correctly communicate with the public.

Acknowledgement
This research was not funded by any grant.

References

[1] Azlan, Arina Anis, Mohammad Rezal Hamzah, Tham Jen Sern, Suffian Hadi Ayub, and Emma Mohamad. "Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia." *Plos one* 15, no. 5 (2020): e0233668. https://doi.org/10.1371/journal.pone.0233668

[2] Romano, Alessandro, Chiara Sotis, Goran Dominioni, and Sebastián Guidi. "The scale of COVID-19 graphs affects understanding, attitudes, and policy preferences." *Health economics* 29, no. 11 (2020): 1482-1494. https://doi.org/10.1002/hec.4143

[3] Menge, Duncan NL, Anna C. MacPherson, Thomas A. Bytnerowicz, Andrew W. Quebbeman, Naomi B. Schwartz, Benton N. Taylor, and Amelia A. Wolf. "Logarithmic scales in ecological data presentation may cause misinterpretation." *Nature Ecology & Evolution* 2, no. 9 (2018): 1393-1402. https://doi.org/10.1038/s41559-018-0610-7

[4] Kasdan, Junaini, Rusmadi Baharudin, and Anis Shahira Shamsuri. "Covid-19 dalam Korpus Peristilahan Bahasa Melayu: Analisis Sosioterminologi." *GEMA Online Journal of Language Studies* 20, no. 3 (2020). https://doi.org/10.17576/gema-2020-2003-13

[5] Steinmetz, K. "Coronavirus: A glossary of terms to help you understand the unfolding crisis." *Time. Accessed on the 7th of April* (2020).

[6] Wee, Liang En, Yvonne Fu Zi Chan, Neville Wei Yang Teo, Benjamin Pei Zhi Cherng, Siew Yee Thien, Hei Man Wong, Limin Wijaya, Song Tar Toh, and Thuan Tong Tan. "The role of self-reported olfactory and gustatory dysfunction as a screening criterion for suspected COVID-19." *European Archives of Oto-Rhino-Laryngology* 277 (2020): 2389-2390. https://doi.org/10.1007/s00405-020-05999-5

[7] Swart, Arthur James, and Marietjie Havenga. "Correlating learning outcomes to the graduate attributes of the International Engineering Alliance in a problem-based learning module." In *2019 IEEE Global Engineering Education Conference (EDUCON)*, pp. 34-38. IEEE, 2019. https://doi.org/10.1109/EDUCON.2019.8725250

[8] Isa, Che Maznah Mat, Nik ‘Irfan Aiman Mohammad, Nor Hayati Saad, and Preece Christopher Nigel. "Programme outcome attributes related to complex engineering problem capability: Perceptions of engineering students in Malaysia." *Asian Journal of University Education* 17, no. 4 (2021): 95-105. https://doi.org/10.24191/ajue.v17i4.16220

[9] Stolz, Michael. "The history of applied mathematics and the history of society." *Synthese* 133 (2002): 43-57. https://doi.org/10.1023/A:1020823608217

[10] Schäfer, Mike S. "The Science of Science Communication: What it is and why it matters." *A comprehensive guide to Science Communication* (2021): 6.

[11] Yusof, Yudariah Mohd, and Roselainy Abdul Rahman. "Mathematics education at Universiti Teknologi Malaysia (UTM): learning from experience." *Jurnal Teknologi* (2001): 9â-24.

[12] Tall, D. 1991, *Advanced Mathematical Thinking* (Dordrecht: Kluwer Academic Publishers)

[13] Gravemeijer, Koeno, and Michiel Doorman. "Context problems in realistic mathematics education: A calculus course as an example." *Educational studies in mathematics* 39, no. 1 (1999): 111-129. https://doi.org/10.1023/A:1003749919816
[14] Stephen, Adam. "Using learning outcomes-A consideration of the nature, role, application and implications for European education of employing'learning outcomes' at the local, national and international levels." *University of Westminster, Edinburgh* (2004).
[15] Kermack, William O., and Anderson G. McKendrick. "Contributions to the mathematical theory of epidemics--I. 1927." *Bulletin of mathematical biology* 53, no. 1-2 (1991): 33-55. https://doi.org/10.1016/S0092-8240(05)80040-0
[16] Box, George EP. "Science and statistics." *Journal of the American Statistical Association* 71, no. 356 (1976): 791-799. https://doi.org/10.1080/01621459.1976.10480949
[17] Katella, Kathy. "Our new COVID-19 vocabulary—what does it all mean?." *Yale medicine* (2020).
[18] Lee S, & Matsuo, A 2018 *Electoral Studies* **51** 1-13. https://doi.org/10.1016/j.electstud.2017.11.005
[19] Nilson, Linda B. *Teaching at its best: A research-based resource for college instructors*. John Wiley & Sons, 2016.
[20] Hughes-Hallett, Deborah, Andrew M. Gleason, and William G. McCallum. *Calculus: Single and multivariable*. John Wiley & Sons, 2020.
[21] Knill, Oliver. "On the Harvard consortium calculus." *Retrieved October* 18 (2004): 2010.
[22] Rosen, J., and D. Klein. "What is Wrong with Harvard Calculus?'." *Mathematically Correct. Retrieved on June* 9 (1996): 2003.
[23] Zhong, Bao-Liang, Wei Luo, Hai-Mei Li, Qian-Qian Zhang, Xiao-Ge Liu, Wen-Tian Li, and Yi Li. "Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey." *International journal of biological sciences* 16, no. 10 (2020): 1745. https://doi.org/10.7150/ijbs.45221