STEM Near Peer Guidance for Secondary School Students: University Mentors' by Prediction System with Online Guidance

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Abstract
The achievement of secondary students and the steady decline in science and mathematics interest is a critical domain for industry, governments, and the education sectors. If countries are to include Science, Technology, Engineering, and Mathematics (STEM) in their current and future workforce, enhancing student engagement in the disciplines of science, technology, engineering and mathematics STEM is a priority. This is crucial to meet the demand for based skills. Among the strategies to overcome such concerns, peer guidance programs have risen in importance. Although prior research has shown that guidance may be an effective model, considering positive outcomes for participants becomes more challenging due to the lack of a system to analyse and monitor student's performance and progress. This study reacts to recommendations for more study on the mentoring processes that influence the efficacy of STEM peer mentoring programs. We look at how mentoring relations are formed between regional secondary school students and university students in the online peer mentoring predaction model Science, Technology, Engineering, and Mathematics Mining (STEMM). We examined quantitative and qualitative data on the engagement quality of relatives and mentors together with their mentoring strategies during the two and half month period. Online guidelines are deliberated, comprising a model that incorporates university-to-school guidance and facilitate to enhance student engagement in STEM.

Keywords: Near peer mentoring, STEM engagement, Peer learning relationships, Online mentoring

Introduction
Everyone is talking about the COVID-19 (coronavirus) pandemic and its consequence to the pandemic's global repercussions. Consequently, education has encountered significant transformations, with the growth of online learning, in which instruction is performed remotely via digital platforms. STEM education is known as integrated learning in the disciplines of Science, Technology, Engineering and Mathematics. This Integrated STEM approach involves science, technology, engineering and mathematics disciplines that apply real-world contexts by connecting education and community institutions to produce STEM-literate talent and society towards driving national economic development. Therefore, to fulfil this desire, STEM

knowledge and culture must be applied to the community and students in becoming part of the culture to drive innovation from the grassroots level for easier dissemination (English, 2016; Marginson *et al.*, 2013; Moore & Smith, 2014).

As a result, referring to the educational institutions' context, teaching quality is defined as the capacity to fulfil the demands of markets and students. The concept of quality of education institutions indicates providing the services that satisfy the stakeholders, such as students, academic staff, and other participants in the education system, to meet the demand for based skills. Peer mentoring programs, for example, have grown in popularity as a strategy for overcoming concerns. The near-peer guidance mentoring encourages establishing a mentee and mentor to form unique opportunities to incorporate teaching and research in STEM placement/internship.

A variety of initiatives are available to increase STEM engagement and achievement among young pupils. According to Rhodes *et al.,* (2011), mentorship has a good impact on all students, particularly those coming from lower socioeconomic backgrounds who typically lack scientific role models. Mentorship scientists work with teachers and students to set a good example for students to access mentoring opportunities (Sadler *et al.*, 2010; Scogin & Stuessy, 2015). Recruiting university students has gained support from a variety of sources in Australia to expand the mentoring pool, e.g., Commonwealth of Australia (Hepburn & Nottage, 2017).

In mentor-mentee program, advantages are typically realised when the mentor and mentee can interact face to face. Recruitment tactics that develop links between the university and school students in diverse locations are required to universalise the advantages of near-peer mentorship targeted to improve STEM engagement. Coloff *et al.,* (2011) proposal, for instance, acknowledges the value of using online communication technologies to transcend geographic obstacles and provide mentorship to kids in rural and regional locations. Leaving aside the medium, for the time being, prior research has demonstrated that guidance may be a beneficial method. The lack of a method to examine and evaluate student performance and development makes determining beneficial results for participants difficult.

Here, we explore the mentoring procedures connected to the success of STEM peer mentoring programs. Using the online peer mentoring program technique, the mentoring relations between university students and regional secondary school students in Malaysia's southern area are established. According to the research, online learning improves information retention and consumes less time, indicating that the coronavirus's changes are still present. To set the stage for this research, we presented a mentorship model in STEM by looking at the peer-to-peer relationship formation of the mentoring program for university students and secondary school pupils in the region.

Current Study: Research Aims

The increasing prevalence of online mentoring programs and their ability to enhance student engagement and interest in STEM fields need further study. This includes looking into the processes and mentor-mentee relations that support efficient student mentoring. The primary purpose of this research is to examine mentors' experiences in a near-online peer mentoring program involving STEM among university undergraduates and middle school secondary students. This also includes categorizing techniques to improve STEM online mentoring's capability. We use the approvals of Zaniewski & Reinholz (2016) and Lagubeau *et al*., (2011) to track the growth of mentoring relationships and analyse the activities that they involved in. Mentors can influence the establishment of students' interest and attitudes in STEM subjects and STEM-related professions throughout the mid-years of education. Note that this is a unique setting to examine STEM mentoring. This research aims to answer the following questions in particular:

1. What strategies do mentors employ to engage mentees and develop effective online mentoring relationships?

2. What changes to the quality of mentoring relationships do mentors report throughout the program?

3. What challenges do mentors encounter in online mentoring environments, and what strategies can be put in place to support online mentors in STEM programs?

This research utilises a mixed-method approach to examine how mentors form and maintain online mentoring relationships, what techniques they employ to engage mentees, and how they deal with the problems that come with online mentoring. With the goal of enlightening factors influencing the establishment of online mentoring relationships, we use a convergent parallel design by (Creswell & Clark, 2017) to gather and merge qualitative data on mentors' perceptions of building relationships and weekly post-mentoring reflections. Furthermore, the study of mentors' perspectives on relationship evolution offers crucial insights into the kind of support that mentors may require to engage in productive online near-peer mentoring relationships.

Methodology

Review mentoring programs in STEM is a full systematic review in examining and exploring different student mentoring characteristics. However, this does not explicitly refer to the mentor mentee's experience and the process (pre and post inclusion of mentor-mentee interaction). In these studies, qualitative and quantitative methods assess the model's effectiveness, including triangulation such as interview, documents, and questionnaire to obtain a more holistic understanding of the model. These are explored quality concepts required by mathematical and science physics knowledge and skills used for successful studies. Additionally, it introduces students to the nature of university mathematics with characterising activities, formal concepts facilitating student's confidence, problem-solving skills, experiences with proof and learning, mathematics and science physics, and appropriate interest in online peer mentoring programs.

The term includes cognitive and social engagement, as well as components of efficient guiding mentoring and relationship’s philosophy. The mentors were also instructed on how to utilise online communication resources and tools (online activities, video and screen sharing and quizzes) as well as techniques to engage students in the online world. The mentors were required to discuss physics science subjects (those taught in the Mentis class), as well as the students’ objectives, the STEM education and career route. The mentors arranged their sessions with the help of classroom instructors, who gave information on the subject taught throughout the two-and-a-half-month(s) period. They also had access to an online repository of multimedia and activities materials grouped by school curriculum topics.

Data Collection

Data was collected during the extended pilot test of the guidance program. They were requested to fill out a pre-placement questionnaire regarding their desire to become mentors, confidence in their mentoring skills (on a point liqueur scale), for example, in a qualitative study of a mentoring program between STEM undergraduates and high school studens and type of expectations. With a Five-point scale expectations about the type of tasks and discussions they would engage in with their mentees, and foreseen challenges where it is quite simple for the interviewer to read out the complete list of scale descriptors (‘1 equals strongly disagree, 2 equals disagree’) (Dawes, 2008).

Tasks and discussion topics in which they relate to their mentors and challenges to anticipate are discussed more detail here. The questionnaire also lists strategies that teachers can use to improve the quality of mentoring relationships, such as peer mentoring methods described in the literature, as well as areas for discussion. They were adapted from the literature on the characteristics of effective mentors, for example, the formation of students' interests, as well as factors related to measures of social and cognitive congruence (for example, the use of practical examples and self-disclosure). At the end of each weekly mentoring session, mentors completed a post-session questionnaire detailing what was covered during the session, how it was arranged, student involvement and mobility, and how it was followed upon. In order not to disclosed the names whom answering the questions, a unique personal code was used to affiliate the participants’ answers during the mentoring week. In addition, the questionnaire contained a list of tactics that mentors may employ to improve the mentoring quality relationships, as outlined in the peer guide literature and the conversation/discussion areas. These were based on qualities of good mentors (for instance, focusing on students’ interests), incorporating cognitive and social connection variables (e.g., the usage of real-life examples, self-disclosure).

Method

Based on these study objectives, the main research objective is presented. This can be ideal for STEM in better understanding the association between learning behaviours, including its positive and negative performance. The main research objective can be answered via the following subsidiary research objectives:

I. Do mining educational data help to identify students' performance early?
II. Do students' performance in the science and mathematics subject(s) courses can serve as indicators of a good or low students' performance in the Physics exam?
III. Which behavioural patterns/attributes lead to positive or negative performance?

To address these research objectives, this study employs the Science, Technology, Engineering and Mathematics using Data Mining techniques (STEMDM) model clustering, classification and association rule mining for the following aims:

I. To predict student performance in Physics courses based on their performance in Math and Physics courses.
II. Examine the impact of behaviours learning on the students' performance.
III. Develop a model that will help extract knowledge about progressions of students' performance during their studies and relate them with their performance in the indicator courses. The results of the experiments are expected to provide answers to the primary research objective.

The following assumptions are made in this study.

- This study supposes that the model can help teachers deliver and students achieve good marks in Math and Science subjects, who were likely to be more successful and perform better in the Physics exam.

- Thus, to pass in these subject(s), students must have at least a reasonable level of understanding of Math and Science subject(s). In this regard, this study supposes that the students who could get a good mark in the Mathematics, Physics and Science were likely to be good students and successful. Hence, they perform better in the other courses.

Finally, this study seeks to investigate the correlation between the monthly exam results and final exam performance. Monthly exams are the most important learning component in most courses in Malaysia. In these monthly exams, students could experience the real exam situation in solving questions like those presented in their final exam. In this regard, this study supposes that the monthly exam performance has significant effects on students' readiness for the final exam; hence, performing better in the final exam.

To derive precise conclusions and facts regarding the two most extensively utilised data mining methods in a concise manner, namely the clustering and classification approaches, we employed an algorithm of Relief ranking and particle swarm optimisation, respectively. The goal is to create an intrusion prediction system

employing an ensemble of Linear discriminant analysis and Logistic regression (classifiers and clustering). The suggested predictions system in data mining-based ideas is depicted in Figure 1 (Sharpe *et al.*, 2019).
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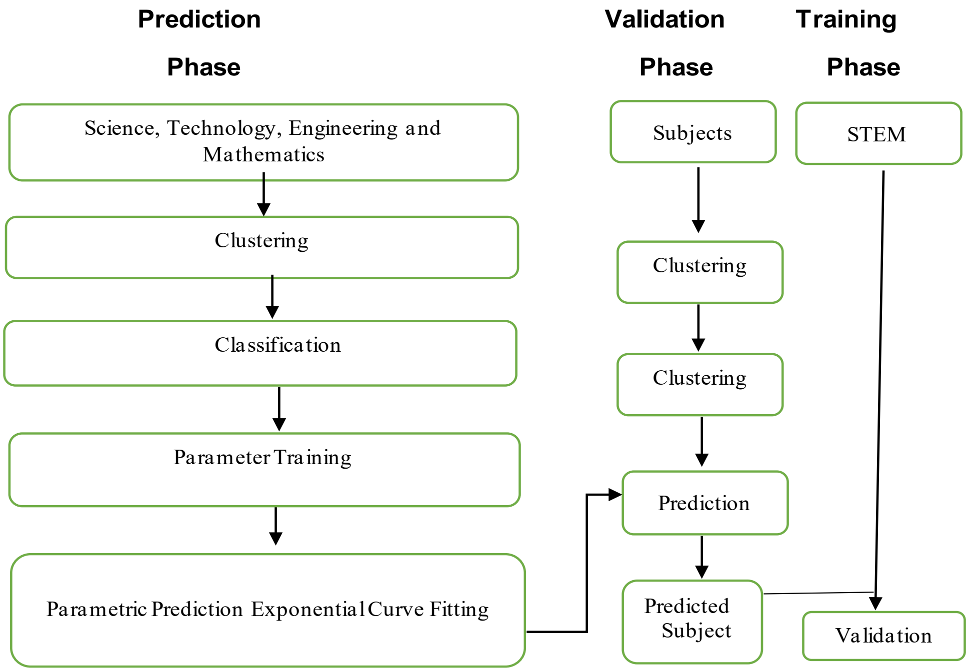

Figure 1: The framework of the proposed Technology, Engineering, and Mathematics Mining (STEMM) model.

The framework has the following main phases:

I. Dataset Normalisation: This is important in categorisation. In general, classification algorithms entail scaling the output of data to fit into a narrower acceptable range. When working with characteristics on multiple scales, normalisation is usually necessary. Given the real-life network data being utilised, which is loud, unreliable, and boisterous, this is a critical component. Here, the decimal scaling approach was used to normalise the data for this study.
II. Data Clustering: Algorithms, such as K-Means, were used to carry out the selection step. To acquire data from the refined subset, the ensemble classifier will be trained using the revised data received from each procedure.
III. Classification: This stage makes use of sci-kit learning to create a bagging ensemble. To boost classification accuracy, the ensemble technique combines logistic regression and linear discriminant analysis.

Results and Discussion

For the result, firstly the data was portrayed on the "pre-guidance expectations and confidence in their mentoring skills" model. The model opinions were then summarised on the quality of the relationship, the frequency, and the relevance of the specific prediction strategy on model placement. Finally, the qualitative data findings on the summary of student's exams were depicted, including an understanding of mentor engagement. The comparison of the student's success in Mathematics versus Physics was presented as high, moderate, and low marks (Table 1) following Sharpe *et al.,* (2018).

Table 1: Comparison of the student's success in Mathematics versus Physics

Mathematics			Physics		
High	Moderate	Low	High	Moderate	Low
55	110	35	101	67	32

Mentors' Perceived Relationship Quality Indicators

From this study, mentors reported that the relationship gained strength, where the mentor-mentee link got stronger throughout the 9-week online mentoring program (Table 2). Mentors' evaluations of mentee advantages were the greatest of all relationship variables, whereas negative signs (frustration and feeling distant) stayed low. Mentors' assessments of communication ease and frustration levels had large standard deviation coefficients, indicating that their mentoring experiences were varied. All of the relationship indicators changed during the mentorship program. The graph below depicts how mentors' experiences and perceptions of their mentees changed over nine weeks of mentoring (Figure 2). Although all measures increased as mentoring assignments proceeded, relationship quality as well as the prevalence and significance of specific mentoring strategies over the mentoring placement. In the end, we present qualitative data results on mentors' session summaries, including the perception of the mentors and the subjects involved. views decreased somewhat in certain weeks. In the sixth and eighth week, mentors' perceptions of distance grew. Similarly, frustration with mentoring climbed in the eighth week but stayed below neutral for the remaining weeks. The perceived ease of communicating with mentees rose in the fifth week and then began to drop in the following weeks. It dropped to its lowest point in the eighth week, then increased in the last week of mentorship. Mentors indicated that mentees' desire to learn held strong throughout the program, with a significant rise in the final mentoring session. This tendency was replicated in mentors' perceptions of mentee advantages received from involvement. Eventually, except for the seventh and ninth week, the strength of the mentor-mentee link remained neutral. Mentors' perceptions of the connection strengthening maintained at their greatest in the program's middle and final weeks, with lower levels in the second and sixth week.The research on peer mentorship acknowledges that scientific role models have a good influence on high school students. Enhanced academic achievement (Appels *et al.*, 2018; Henthorn and Pluth, 2015), richer attitudes toward science (Marcy *et al.*, 2014; Simpkins *et al.*, 2006) and self-confidence are all advantages of mentoring (Battich *et al.*, 2013).

Table 2: Average scores for relationship quality indicators over nine weeks of mentoring.

Indicator	Mean	Standard Deviation
Relationship getting stronger	M=3.89	SD= 0.071
Feeling distant	M=2.89	SD= 1.020
Feeling frustrated	M=2.23	SD= 1.147
Strength of bond	M=3.78	SD= 0.541
Willingness to learn	M=3.67	SD= 0.509
Benefiting from mentoring	M=4.03	SD= 0.446
Ease of communication	M=3.88	SD= 0.982

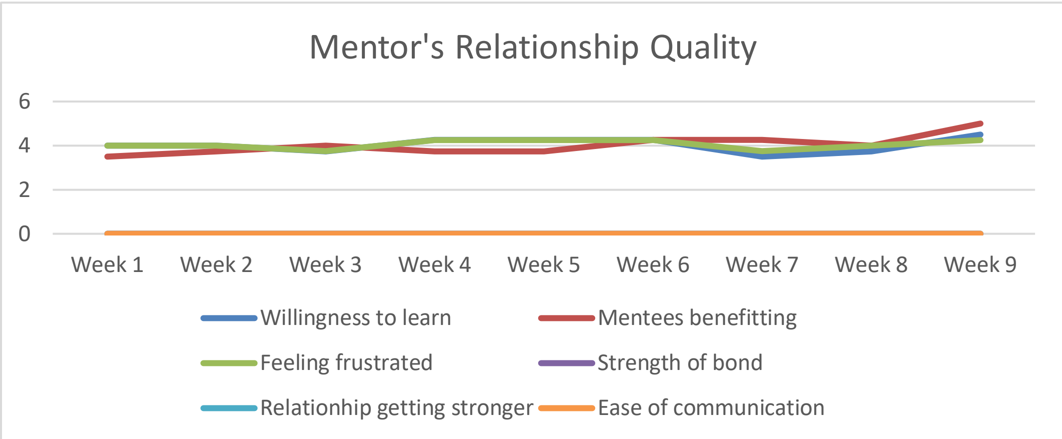

Figure 2: Mentors' relationship quality mean scores over nine weeks of the mentoring period

Strategies Employed by Mentors

The important of mentoring initiatives during this program was on average (Table 3). The replies of mentors were diverse, implying that various mentors had diverse perspectives on the relevance of each method. Mentors asked students for involvement in planning and conducting their sessions (i.e. asking mentees what they would want to talk and do during mentoring sessions), with mentors discussing scientific and mathematical concepts and utilising practical examples (i.e. mathematics and science applications). Study techniques were rarely mentioned in terms of relevance, where mentors did not claim that sharing their personal learning issues was a common method. Mentors' opinions on the importance of these tactics differed once again. This could be due to small sample size which possibly contribute to the high variability.

Table 3: Average importance of mentoring strategies and actions.

Indicator	Mean	Standard deviation
Asking for students' input	M=4.33	SD=0.713
Understanding students' science interests	M=3.77	SD=1.183
Mentor sharing own school experiences	M=3.49	SD=1.422
Mentor sharing university experience	M=3.33	SD=1.179
Mentor sharing own interests and aspirations	M=3.37	SD=1.266
Mentor providing resources	M=3.52	SD=1.463
Mentor explaining science topics	M=4.22	SD=1.354
Mentor using practical examples (e.g. real-life applications)	M=4.33	SD=1.308
Mentor using examples to raise mentees' interest (e.g. suited to mentees' interests/aspirations)	M=3.88	SD=1.341
Showing study strategies	M=1.86	SD=1.530
Mentor sharing own learning challenges	M=2.55	SD=1.638
Talking about science career opportunities	M=2.89	SD=1.671

The achievement of the mentors' experiences as part of a pilot STEM mentoring program that matched university students and secondary school students in regional areas. It sought to contribute to the peer mentoring literature by exploring mentors 'strategies and challenges associated with providing STEM mentoring through online communication tools. However, the findings of these researches suggest that online mentoring programs could be employed to increase students' engagement in STEM if particular aspects of the mentor-mentee relationship are taken into consideration when designing and implementing these programs. Therefore, there is a need for presented the prediction model can provides an overview of the methodology by which this study was conducted. The study states the objectives tested and their results, which were directly measured and proved. Next, it introduced the research design and data source, followed by a discussion of how the datasets and applying the Technology, Engineering, and Mathematics Mining (STEMM) model in conducting the experiments. This is in aggrement with Joshi and Kumar (2014) who stated that STEMDM model, such as clustering, classification, and association rule mining, can offer more meaningful results, way beyond the statistical analyses.

Conclusion

In this study, we successfully described how the STEMM model, including data mining algorithms, offers a great promise in organizing the student data and offering a great deal of a system that can assist the teacher in maintaining the student's performance all over the semester from one level to another level thus achieving the research goals.

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