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Individual student key performance using mobile web apps based on knowledge profile and cumulative grade point average

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ABSTRACT

This study investigated the performance of individual students toward the knowledge profile and cumulative grade point average or known as CGPA. The proposal of this paper involves two major components. The first component is investigating the individual student performance based on the knowledge profile and CGPA. The performance of students from cohort 2017 for the program Bachelor of Electrical Engineering (BEKG) courses in the Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM) was used as the dataset. The case study separates into various groups (excellent, honors and pass). Secondly, the study proposed a responsive web application leveraging a Google Visualization Feature to self-check individual academic performance. The goal of this app is to assist users in evaluating individual student performance and assist management in planning for continual quality improvement using the web and mobile apps. The marketing segments include students, academics, university, and school administration for analysis and evaluate the individual student's performance.

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1. INTRODUCTION

In line with the country's development and to meet industrial demands, institutions of higher education (IHLs) have recently attempted to provide students with both hard skills, such as cognitive knowledge and professional skills [1]–[3] and soft skills [4], such as problem-solving [5] and teamwork [6], [7]. Future investigations related to this issue can be found in [8]. Due to these issues, IHLs, including the engineering program, used a cumulative grade point average (CGPA) as a key performance to measure the overall academic standing in the decade. Various studies have been conducted to evaluate the effects of the CGPA on the student's academic performance [9]–[12]. However, many employers still believe that a CGPA of 3.0 or higher demonstrates competence and capacity to perform the job and hence use it to screen candidates for an initial interview [13]. Although the CGPA significantly impacts the interview selection process, it has only a minor impact on the outcome because the interview is all about how he presents himself to the firm [14].

Other than CGPA, the key performance of engineering student has also been measured using outcome-based education (OBE), and it has been reinforced by the most academic institution which offers engineering courses in Malaysia [15]–[19]. The graduates and professional engineers must register as members of the Board of Engineers Malaysia (BEM) engineers under the Registration of Engineers Act 1967 (Revised 2015), and the prerequisite for the registration as a graduate engineer is a qualification in engineering recognized by the BEM. The responsibility of IHLs is to ensure that the engineering program must meet the standard outlined by

Engineering Accreditation Council (EAC), the body represented by BEM, The Institution of Engineers Malaysia (IEM), Malaysian Qualifications Agency (MQA) and the public services department '*Jabatan Perkhidmatan Awam Malaysia*' (JPA).

The engineering program accreditation standard 2020 includes elements of outcomes in the engineering curriculum to ensure a continual quality improvement (CQI) culture in the spirit of OBE. When Malaysia signed on as a provisional member of the Washington Accord through the EAC in 2003, one of the keys focuses of academic institutions in Malaysia was the adoption of OBE [15]. An engineering program must build a knowledge profile based on the program outcome (PO) mapping, and basically, an engineering student develops the knowledge profile in 4 to 5 years of study. Knowledge profile is an important element that will develop students' ability to analyze the problem, synthesize the solutions and create responsibilities for the environment and community as a graduated engineer. Since Malaysia followed the Washington Accord, in this study, the knowledge profile is referred to as the definition of knowledge (WK) profile. Figure 1 shows the mapping of WK with POs. There were eight WKs have been outlined and mapped to PO1 to PO8 by the EAC. Table 1 shows the definition of each WKs.

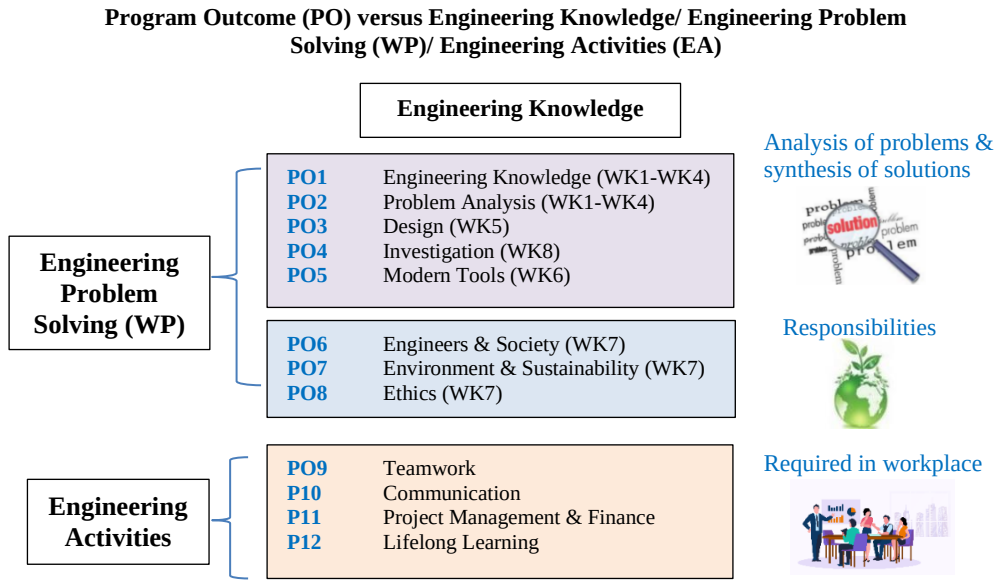


Figure 1. Summary of PO components versus knowledge profile [20]

Table 1. Definition of knowledge (WK) profile [20]

	Definition
WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline.
WK2	Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge that supports engineering design in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability.
WK8	Engagement with selected knowledge in the research literature of the discipline.

According to Öz and Boyacı [21], student engagement strongly explains students' CGPA, which contributes to good and important student outcomes. Some engagement dimensions can even mediate between student characteristics and outcomes. Based on the findings, future research is needed to fully grasp the impact of participation in student outcomes in developing countries. However, Öz, and Boyacı [21], student outcomes are limited to student achievement, satisfaction and pursuing postgraduate studies. In addition, numerous studies have demonstrated that student involvement may influence student achievement [22]. For instance, Ismail [23] claimed that a higher CGPA does not always help graduates get jobs. However, these qualitative

findings are still questionable as the sample does not consider student attainment, particularly for engineering students. While Hashim [24] conducted a quantitative study to test the hypothesis that there is a relationship between employee performance and CGPA.

Employers may not look solely at CGPA as a significant employment factor [25]. Thus, equipping graduates with a knowledge profile may bring extra merit. However, despite CGPA, the lack of soft skills and durability and the selective attitudinal jobs tend to turn down employers who want to hire graduates. As a result, the graduate employability program has grown in importance as a platform for producing quality employees for the competitive labor market. In addition, there was a clear mismatch between labor market expectations and local graduates' specialized employability abilities [26], [27]. As a result of the mismatch in skills between graduates and employers, a rising proportion of Malaysian graduates are unable to find work even after six months after graduation. Motivated by the promising results in our previous works [28], this paper continues on our line of research and devises individual key performance with CGPA. In this paper, we investigate the correlation between WK profile and CGPA for various groups of students: excellent, honors and pass. The calculation for generating the individual WK profiles is also discussed. Furthermore, this paper also develops an individual student key performance using mobile web apps based on WK profile and CGPA. The apps will greatly help identify cohort performance (macro-level) and individual performance (micro-level), which is very important to perform the CQI. Finally, we provide some suggestions for improving the WK profile study.

2. BUILDING DATA SET

This study aims to investigate the performance of individual students toward the WK profile and CGPA. The case study separates into various groups based on CGPA performance, as shown in Table 2. The dataset used in this analysis was the performance of students from the 2017 cohort who graduated recently in 2021. It is worth noting that the total number of students enrolled in the 2017 cohort is 173, with 10 outstanding, 62 honors, and 101 pass grades determined by their CGPA categories. Through an analyzing-based study on an existing data CGPA and computation of individual student knowledge profile attainment, this study seeks the following information: i) What insight can best describe the discrepancy between the eight elements of the WK profile and CGPA in the students' performance?; ii) What best describes the association between WK profile-specific characteristics and CGPA in students' performance?; iii) How will results from the WK profile comparison provide a significant CQI contribution to program (macro-level) and student (micro-level) performance?

Table 2. Grade point system used in the proposed dataset

Group	Grade point
Excellent	3.70-4.00
Honors	3.00-3.69
Pass	2.00-2.99

2.1. Data extraction

To generate individual WK profile for each student, $j \in \{1,2,\ldots,8\}$ represents the number of a knowledge profile W_j. N_j is the total number of courses mapping to a knowledge profile W_j and $p_{i,j,k}$ is a percentage of course k, $k \in \{1,2,\ldots,N_j\}$ from student for i. Then, $w_{i,k}$ and $c_{i,k}$ represents a weightage component of $W_j^{i,t}$ and a credit hour for course k. Individual student knowledge profile attainment, denoted by $W_j^{i,t}$, for student i from cohort t can be evaluated by (1).

$$W_j^{i,t} = \frac{\sum_{k=1}^{N_j} w_{i,k} c_{i,k} p_{i,j,k}}{\sum_{k=1}^{N_j} w_{i,k} c_{i,k}} \quad (1)$$

2.2. Mobile web apps

Technology mobile has made a huge impact in many areas, especially in education which is gaining a great benefit from having a mobile web app–a feature-rich responsive web design optimized for a mobile experience. The mobile web apps are downloaded and installed using an app store and is intended for interaction between the user and the application different with a website, which is content displayed to the user and is not meant for interactions. The purpose of websites is to display static content to the user—for example, portfolios, official websites of brands. Figure 2 illustrates that the app incorporates the Google Visualization Feature to assist students in achieving their degree with knowledge profiles and CGPA.

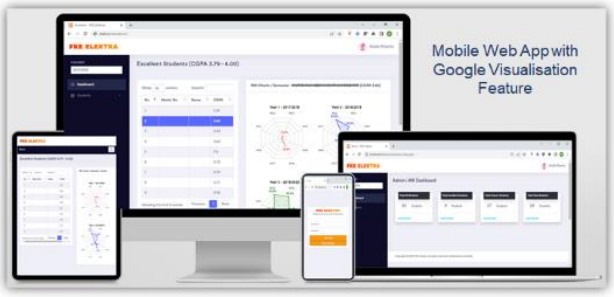


Figure 2. Mobile web app

2.3. Development approach

The mobile web app was developed in this study according to the comprehensive four-stage process: planning, design, implementation and operation [29], [30]. Figure 3 lists the development process for this app with a brief description of each stage. The requirement specification is produced once the app's needs are gathered and analyzed. From that specification, the app is designed for simplicity and ease of use. Next, the app is implemented, including databases, interfaces and codes according to the requirements and then ready for testing to evaluate user experience, functionality, and performance. Finally, the app is deployed for use.

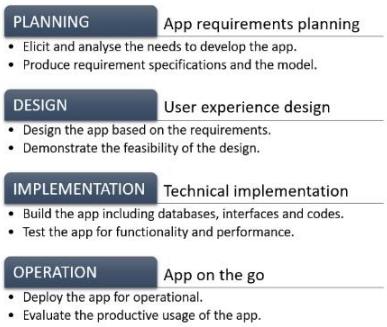


Figure 3. App development process

Figure 4 depicts the architectural perspective of how the app integrates with critical parts to achieve the app requirements. The app was developed in PHP (scripting) with MySQL (database). The algorithm is designed by leveraging the Google Visualization Feature to dynamically generate radar charts to visualize the WK Profile of the student performance. The data to generate the chart is extracted from the student information system, specifically on the PO and CGPA values.

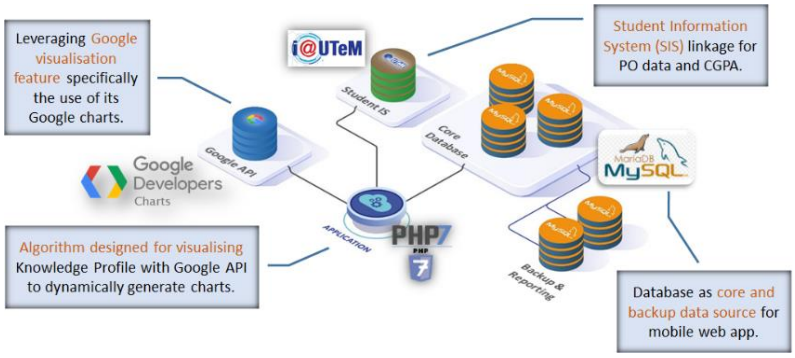


Figure 4. Architecture of mobile web app

Once the process of calculating the WK is analyzed, it is then reflected in the database-specific implementation of the data model, specifically the entity-relationship (E-R) model as seen in Figure 5, for the data to be stored in a database. It also covers the possibility of the app to use by different fields of engineering students, particularly when it comes to future expansion. One of the core entities in the E-R model is the LOPO entity that holds a student's marks for each learning outcomes (LO) and program outcome (PO) of each course (refer to the attributes of the CMMAP entity). Therefore, when implementing the codes, the LO and PO attribute with reference to the WK entity from learn out entity will be mapped with the similar attributes of the CMMAP entity to obtain the course marks in the LOPO entity. This is how the course marks are extracted from the database for WK calculation.

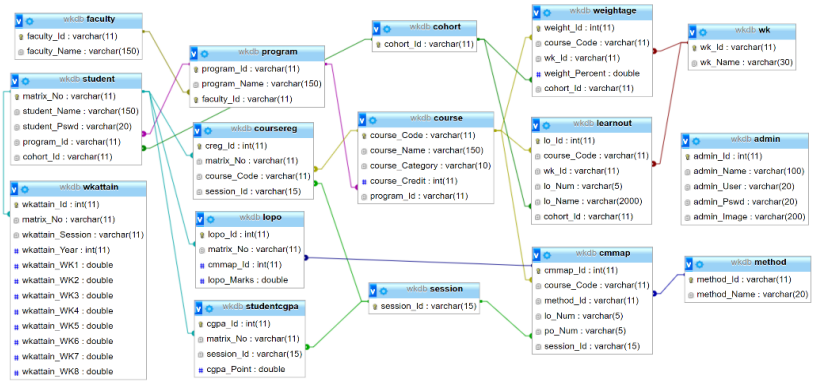
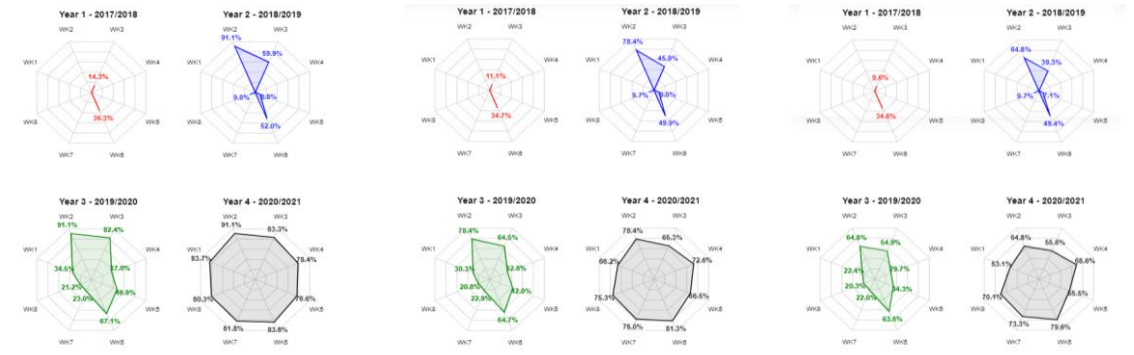


Figure 5. Entity-relationship model for calculating knowledge profile

3. RESULTS AND DISCUSSION

The eight criteria in (1) are assessed on a 0 to 100% scale, with 0 indicating extremely poor WK profile attainment and 100% indicating very high WK profile performance. For instance, Figure 6 shows the overall WK attainment performance based on the case study group. The results are discussed based on case study group. The case study research captures as part of a dual-level evaluation arrangement in which a single evaluation consists of one or more sub evaluations with the potential of case study playing various roles to inform the program evaluation as a whole [31], [32]. From the observation, the web chart grew from year 1st to year 4th based on the corresponding WK throughout the program. Besides, it can be seen that WK attainment achievement for the excellent group are outperforms than honor and pass group of students. Thus, it indicates that the CGPA categories influenced the WK attainment performance. From Figure 6(a), overall WK profile attainment of the excellent group student was less performed in WK4 and WK5, which indicate knowledge in an engineering discipline and supports engineering design in the practice area. However, in honor and pass group students, their WK4 performance are quite higher than other WK profile, which is 72.6% and 68.6%, respectively. It is significant to develop engineering students with problem-solving skills to retain continuity in theoretical, innovative, and creative thinking [5]. From Figures 6(b) and (c), the lowest performance of WK within the honors and pass group is in WK1, representing a theory-based understanding of natural sciences.



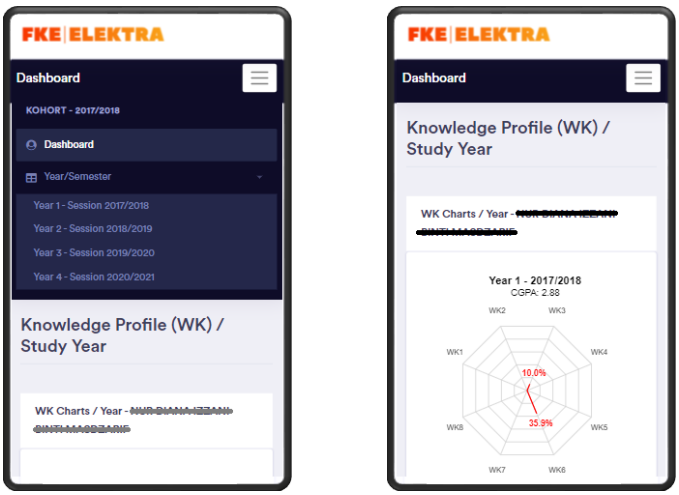
(a) (b) (c)

Figure 6. The overall WK attainment performance based on the case study: (a) Excellent, (b) Honor, (c) Pass

3.1. WK app performance

3.1.1. Student view

The final result of the app development process is the mobile web app that is developed based on specific project requirements and hosted on a dedicated hosting server [33], [34]. The app is used by two users–students and academic advisors as student's most important function of academic guiding [2], [6], [13], [31]. Each user is assigned an access level and must be authenticated to access the app. When students access the app, the student can choose the year of study as seen in Figure 7(a), to obtain the WK radar chart as seen in Figure 7(b), for self-review academic performance. With a desktop view, the student can review their WK academic performance with the course taken according to study year. Figure 8 shows the example of students' layout showing the course taken according to the year of study.



(a) (b)

Figure 7. Layout WK apps for student view: (a) menu for selection, (b) radar chart according to study year

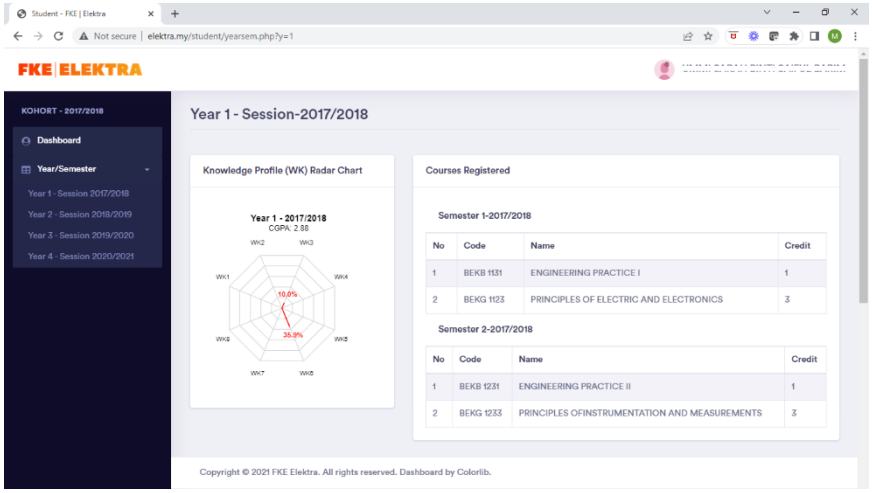
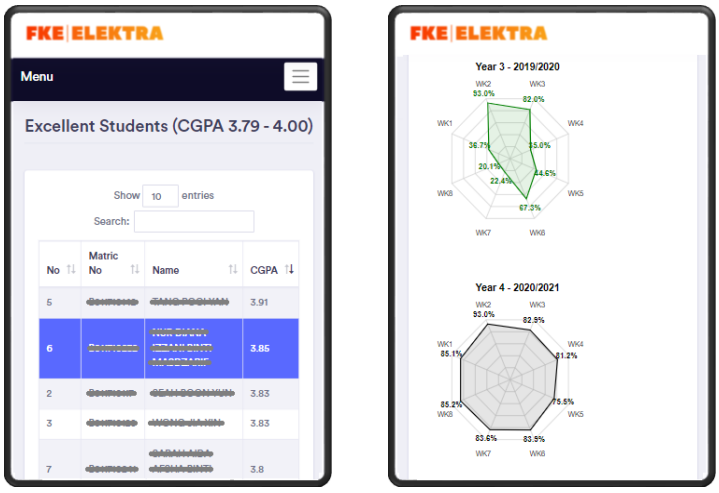


Figure 8. Student's WK with courses taken according to study year

3.1.2. Academic advisor

Subsequently, academic advisors can access the app to see their students' academic performance and assist their students in achieving the right WK level. Figure 9(a) shows a list of excellent students. Meanwhile, Figure 9(b) displays the WK radar chart when clicking at the student's name. The overall WK for each category can also be displayed as an example of excellent students, as shown in Figure 10.



(a) (b)

Figure 9. Example of layout for academic advisor (a) Select a student to view, (b) WK radar chart according to study year

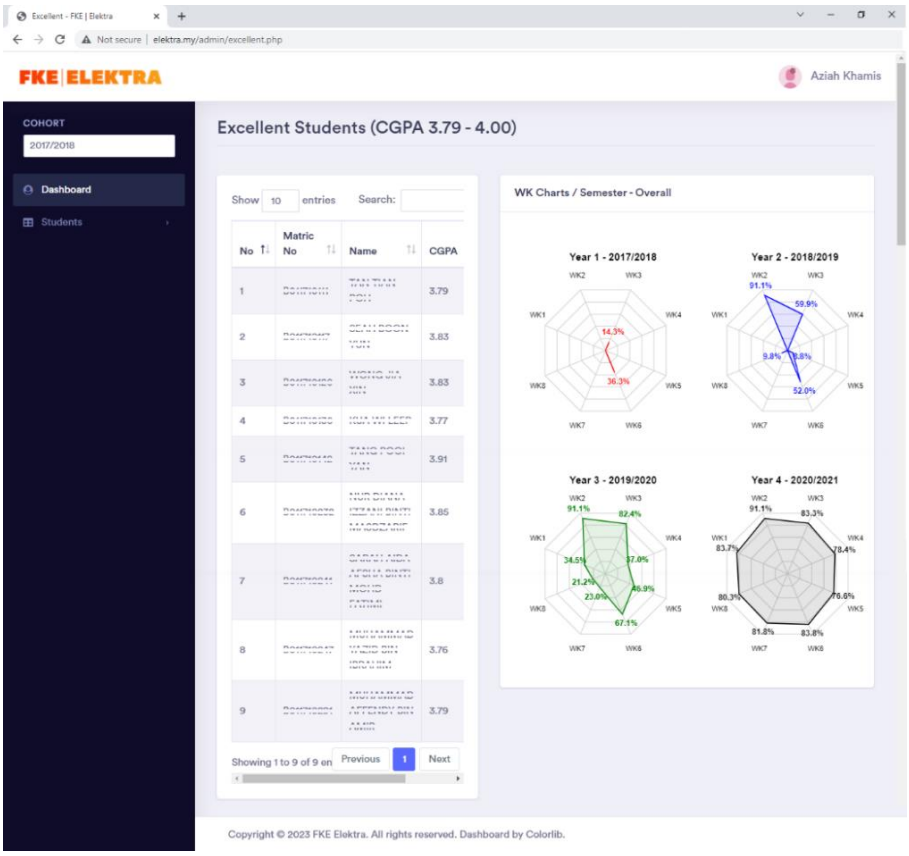


Figure 10. Overall WK for excellent students

3.2. Data analysis

The calculation of the WK profile was evaluated using (1). Each student's official course marks are taken and accumulated from the first semester to the next until the final semester. The process is reflected in the mobile web app. With clear requirements taken into account, the development of the app becomes easier. We also analyze the variance of knowledge profile attainment performance using ANOVA to identify the difference between overall average results from eight WK using a 5% confidence interval [35]. For a fair

comparison of the statistical data, it was assumed that the standard deviation was known for a large and independent number of students for each WK performance. Thus, the following analysis is based on CGPA and knowledge profile attainment performance from 126 students for the 2017/2018 cohort BEKG program. Note that for the analysis in this study, this amount only considers student that has completed the whole WK attainment in their final year with 136 total credit hours. In contrast, the remaining students in the same cohort already receiving a credit exemption upon enrolment are excluded.

Therefore, the significance of the proposed evaluation of the WK profile and CGPA is observed. By reviewing the finding, the management may undergo the CQI for the program, especially in deciding the mapping between PO attainment and WK profile. The mapping error could be detected due to an unmatched value encountered while the dataset was analyzed. For instance, only one subject in the second-year mapping to WK2. As a suggestion, it is advisable to have a common understanding between the management and lecturer on the WK profile. Thus, having a clear understanding on the WK profile, the apps will help each student to monitor the WK profile attainment accurately. Overall, this apps help identify cohort performance (macro-level) and individual performance (micro-level). The apps act as a tool to facilitate student performance evaluation and all WK profile attainment performance.

Each WK profile attainment performance was hypothesized to have some influence on CGPA. The regression analysis results in Table 3 reveal that there is a 95.37% of the variance in CGPA. At the same time, this study attempts to predict CGPA performance based on some predictors. The predictors tested are each WK profile attainment. The results show that only WK8 have a p-value above 0.15, which shows less influence on the CGPA performance. The findings of this study revealed that the CGPA has a weak positive relationship with 7 of the WK profiles. At the same time, WK7 shows a weak negative relationship with CGPA and is statistically significant.

Table 3. Regression analysis predicting CGPA

Item	β	t-value	p -value
WK1	0.0020	1.4608	0.1497
WK2	0.0046	3.6039	0.0007
WK3	0.0216	10.5949	0.0000
WK4	0.0062	1.6965	0.0953
WK5	0.0089	4.2708	0.0001
WK6	0.0087	2.0344	0.0467
WK7	-0.0049	-1.6817	0.0982
WK8	0.0040	1.4262	0.1594

Notes: Dependent variable performance with statistically significant at $p < 0.05$; R^2 =0.9595; adjusted R^2 =0.9537; F =165.9529; significance-F =0.000

4. CONCLUSION

The result in this study proved that the development of web apps based on definition of knowledge (WK) profile and CGPA could visualize the identity of cohort performance (macro-level) as well as individual performance (micro-level), which is very important to perform the CQI. Furthermore, the finding showed that the apps are useful tools for the students, academic advisors, and management in universities or colleges to evaluate the program's performance. Although it is too early to conclude the effectiveness of Malaysia's direction on the WK profile reform, this study reveals that a mutual understanding of the WK profile for each course between the management and the lecturer is needed so that the apps can provide the best-visualized performance. Future research can be done by looking into other elements mapping attainment such as engineering problem solving (WP) and engineering activities (EA).

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