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ICT FACILITATION OF ACADEMIC ASSESSMENT PROCESS INVOLVING INDIVIDUALLY VARIED AND COMPLEX ENGINEERING PARAMETER

Mohamad Irwan P. Harahap[1*]

[1]Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM), Permatang Pauh, Pulau Pinang, Malaysia

*E-mail: mirawan1@yahoo.com.my

1. INTRODUCTION

The advent of the COVID-19 pandemic has assuredly posed a lot of new realities and disruptive challenges to the daily norms of the citizenry across the country. The imperatives at stake are uncompromisable involving human lives and physical and mental health, and the right to receive treatment from the health care providers (The World Health Organization (WHO), n.d.). Coupled with the only possible responses for the moment to this still largely enigmatic disease involves a wide array of restrictions in movement, job performance and personal endeavours, and unfamiliar standard operating procedures (SOPs) involving among other self-protection, self-cleansing and self-confinement, social distancing. The lives and livelihood of the populace have been irrevocably and massively transformed for better or worse, willingly, or unwillingly into uncharted territories. As we speak, the virus has mutated into more contiguous and deadly variants making the vaccination program and other containment measures even more indispensable and pressing. Health experts have warned that even with the rush in the vaccination program and the attainment of the herd immunity, the disease will remain endemic, and most of the ad hoc SOPs and treatment measures prescribed to deal with the current crisis or some variations of those will likely be here to stay for unforeseeable future. The future seems bleak and uncertain indeed.

Equally affected are the education sector involving teaching and learning (T&L) processes in the academic institutions of all levels of education (Daniel, 2020; Gewin, 2020). With the restriction in face-to-face interaction (Daniel, 2020), online learning (OL) (Osman et al., 2009) as well as open and distance learning (ODL) (Levy, 2017) that used to be considered a novelty and taken for granted are now proven to be indispensably essential for even the very basic communication task greatly aided by the ICT platforms such as social media and virtual meetings. In this context, it can also be argued that technologies have progressed beyond essentially informal realm into a formal one. For example, social media used to be viewed as platforms for casual exchange of ideas and thoughts by the masses are now used to broadcast very seriously, wide-ranging consequential messages and business proposals by professionals from presidents to professors. As such, the quick and adequate grasp of the required technologies has become raison d'être on both sides of the divide. No longer generational gap or computing literacy excuses be tolerated currently. Social media and virtual meetings have taken over from the whiteboards and projectors, and they are here to stay. Notwithstanding, there are so many technologies that can do to bring the feel and experience of a real physical presence and not to mention the remarkable possibility of service limitation, interruption, and general breakdown. The starkness of technology could not entirely replace the forbearance of humanity in nurturing living, breathing organisms with free will and self-worth.

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Regardless, while the instruction portion of the virtual T&L goals could be perfected by the lecturers over the course teaching delivery, the same could not be said for the students' erudition process due to the lack of supervisory reach and an inorganic technology approach. Reliance on such committal devices as digital attendance sign-in and engagement timestamp could be fickle and superficial in registering students' assiduous interest, active engagement, and cognitive absorption. The evolution in the education sector is constantly warranted not only to reflect on the con-current development in the field of study but also to meet new challenges posed by the assaults on the academic bastion of integrity due to prolonged stagnation or outgrown familiarity. One of the possible avenues of change revolves around the novelty of realigning or reintegrating technological resources and teaching techniques to achieve specific learning aims. Such realignment must be synergistic, context-specific, well planned, and well-executed with a heightened sense of alertness on the part of lecturers to respond to any potential breach in the system through students' connivance and ingenuity. For no plan survives execution at least not in the long run. The instructor-instructed interaction dynamics will ensure this to be true.

And the one area of learning that is arguably plagued with pervasive and persistent issues of veracity and plagiarism is that of the assessment particularly when accompanying counter measures could not be adequately utilized due to circumstantial constraints and obscurity. Assessments have long been the tools used in the institutions of higher education to gauge students' capacity for learning, and the attainment of which serves as the green light to graduate to the next stage of learning or formal learning qualification. However, for any professional program like engineering reciprocal recognition by accreditation bodies is also imperative for employability consideration or post-graduate program pursuit especially in the public sector and international mobility, and more often than not end-of-the course summative examination would be one of the significant components in that regard (Butler-Henderson & Crawford, 2020). With such emphasis placed on examination in the accreditation of professional qualification, the next puzzle beckoning would be the credibility and validity of such innovative measures as online examinations, e-examinations, and bring-your-own-device models over paper-and-pencil invigilated examinations. While some argued in favour of the former models (Ardid et al., 2015), others were more skeptical highlighting the potency for cheating in contemporary student experience (Rettinger & Rettinger, 2009). Personal experience and logic would suggest agreement with the latter stand. Pursuit of merit and acclaim albeit through learning shortcuts especially if you can get away with it is an intrinsic human-animal trait of survival of the fittest. It was even suggested that focus should be shifted from students' integrity capacity building (Crawford, 2015) instead to cheating detection enhancement (Dawson & Sutherland-Smith, 2019) and contract cheating ban legislation (Amigud & Dawson, 2020). Another possible approach would be to contrive an unconventional question format that would be engaging enough to deny cheaters from profiting through their misdeeds. This initiative involves generating questions with parametric variability, contextual complexity, and time exigency to anticipate collaborative efforts and parallel solution outsourcing while remaining true to the prescribed learning scope and objectives. Naturally, the form of questioning that would lend easily to this kind of manipulations would be of calculation type involving numbers and logic built around scientific, engineering, and mathematical principles. The body of works in this direction is still lacking and it was the premise of this paper to address this shortcoming.

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For this reason, an exploratory assessment approach had been devised whereby a common test with individually varied parameters, but equivalent contextual complexity would be administered to two successive engineering student cohorts under prescribed time exigency. The objective was to gauge not only their respective academic performance but also how this performance would be dictated by devious exploits. The measures used had involved the trend of marks attainment with a penchant for the extent of marks extremity and similarity. To complement the first, the next objective was promulgated to access the efficacy of a pre-developed ICT tool in generating context-specific design results on the fly and subsequently used for marking the individually varied and contextually complex answer scripts. In this instance, the measures used required internal program scrutiny to establish two salient programming characteristics indispensable for multi-faceted engineering computations: iteration and replication. Finally, the objective was to develop a conceptual framework for the reintegration of ICT tools into the online academic assessment process that formulates the prescribed approach generically for further scrutiny by future research endeavours.

2. LITERATURE REVIEW

Application of ICTs nothing new in the realm of education. The broad spectrum of technology-based tools at our disposal such as email, virtual and augmented reality devices, social networking sites, mobile applications, video conferencing, and voice-over internal protocol has facilitated, enhance and optimize the delivery of information and knowledge (Oliver & Clayes, 2014). However, at the beginning perhaps the tools served more as objects of curiosity, research interest, social experiment, or occasional choice in which the full potential in terms of reach and use were not fully realized. In short, largely inconsequentially clustered as far as driving and propelling the universal educational transformation in the age of the fourth industrial revolution. With the onset of the pandemic, a new realization has dawned with little choice but to adapt due to pressing needs to forge ahead. ICTs have now become indispensable in all matters relating to education delivery and management supplanting well-rehearsed traditional face-to-face routines in such areas as T&L processes, administrative meetings, seminars and conferences, academic accreditation, and many more. It follows that more recent studies were carried out to exploit the full potential of the technology and broaden its application even further. Some recent pandemic-era studies on education-related themes are outlined here: T&L in operations management (Tortorella et al., 2021), students' preference of ODL tools (Saidi et al., 2021), modeling of integrated student activities management systems (Jasmis et al., 2021), review of online examination authentication (Butler-Henderson & Crawford, 2020), T&L in postgraduate medical physics (Azlan et al., 2020) and many other exciting works. On the other hand, most of the current and past literary works on online examination themes revolved among others on authentication and security, student perception, interface design, student performance, anxiety, and cheating (Butler-Henderson & Crawford, 2020). There have been great strides made in the understanding and implementation of online technology in examination management over the past decades albeit in disparate and isolated treatments. It would be more prudent to consolidate all pertinent information on this relatively new pedagogy in higher education into a synthesised whole to deliver unified strategical thinking or vindicate an innovative proposition.

On the other hand, challenges to innovative stride do exist and are searingly real particularly in the context of tertiary education. A study attributed the cause to three main factors namely infrastructural inadequacy, acculturation obstacle, and psychological challenge (Alam & Asimiran, 2021). Firstly, the technological disparity in emerging society is

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disparaging (García-Pe˜nalvo et al., 2021). It revolves around technological accessibility, internet bandwidth, and hardware and software availability which vary across socio-economic groups, regional development, and geography. Lack of parity would impede quantitative and qualitative education program delivery across the board. Secondly, acculturation to online education in emerging societies may require a bit of getting used to it (Alam & Parvin, 2021). Course content and delivery platform may not be as matured as in the developed countries, and outright recourse to such external sources might be wanting due to the non-contextual nature of the materials and technology upscaling barriers. Much effort may need to be expended to develop local capacity and resources using available technologies but that could be such an enabling act in the long term. Thirdly, the audience namely students may find online engagement mentally challenging and uninspiring. With the lack of conducive environment, connectedness, and awe factor normally associated with an authoritative physical presence, the mindset might instinctively fall prey to a predominantly subconscious state of reduced awareness and disjunction. This can lead to among others reluctance to speak or ask questions (Alam & Parvin, 2021), an unintended gap between lecturer and students (García-Penalvo et al., 2021), and possible outright disengagement. In addition, other studies indicated issues with students' diverse digital capability (Margaryan et al., 2011), and higher age and gender diversity (Eagly & Sczesny, 2009). For instance, elder generations might have been habituated to doing things in a certain way and might not appreciate nor welcome changes to the status quo especially when it involved reskilling effort and job redefinition. Moreover, it can be contended that the male population is more eager or thrill to pursue and try new technologies out of the production line than their female counterpart. These challenges would have to be fundamentally addressed by all parties concerned before online technology can be considered a contender for the serious, notable, and ubiquitous undertaking.

One of these serious undertakings relates to the assessment process. The adaption of face-to-face assessments including examinations to the online application has been manifested in various guises and forms even before the pandemic. A review of the previous studies on online examination themes was carried out with nine key areas identified: student perceptions, student performance, anxiety, cheating, staff perceptions, authentication and security, interface design, and technology issues (Butler-Henderson & Crawford, 2020). Concerning student perceptions, most nowadays preferred the experience over a paper-based one (Bohmer et al., 2018). In the age of mobile technology, this is understandable due to the convenience afforded by state-of-the-art computers and gadgets in a multitude of task performances over effortful pen and pencil methods. Furthermore, student performance did not significantly differ either (Oz & Ozturan, 2018). However, provisions must also be made against opportunistic exploits and fraudulent efforts on the part of students. Next, the anxiety level was mixed (Stowell & Bennett, 2010) and students attested that cheating was made relatively easier online (Aisyah et al., 2018). Understandably, staff perceived cheating and technology reliability as the biggest concerns but commended the ease afforded in examination management (Schmidt et al., 2009). Since cheating was of such a paramount concern, if not checked it could play an insidious role in jeopardising the assessment results validity and acceptance, and by inference the integrity of the academic program. Validating and authenticating examinees were also items of concern online (Chao et al., 2012). Cyber-attack strategies and incidences are well established globally involving circumvention of pre-configured security restrictions and gaining fraudulent access to unsuspecting institutional systems for malevolent purposes such as stealing, modifying, appending to, or wiping out existing records. Finally, a features-rich interface (Abdel Karim & Shukur, 2016) and access to university infostructure over personal system (Pagram et al., 2018)

was also suggested. Program interactivity and system integrity certainly ensure the effective and efficient running of the online examination.

Based on the preceding discussions, many works have yet to be done to address the many grey areas in the field of online education specifically relating to online assessment. Specific techniques to nullify potential cheating attempts in the online assessment are still lacking. Furthermore, the structure of the questions that could not be easily compromised by cheating attempts is also not adequately treated. Finally, the ICT infrastructure prerequisites for such a well-thought-out approach could just be rudimentary enough utilizing pre-existing resources to warrant further monetary investment in technology.

3. METHODOLOGY

This study was based on a quantitative research method involving marks attainment on a particular singular assessment type. The selected assessment was a common test involving written engineering design works, subjective and administered individually, and on par with parallel engineering courses' examination scope and content. It was duly selected because it constituted a significant chunk of the overall course marks, predominantly calculation-based, generally regarded to be difficult, and thus more readily susceptible to manipulative attempts especially under limited supervisory visibility. Another category of assessments was not considered in this study due to them being either a collective effort or requiring external party involvement. As such, the derived partial marks from the common test assessment had been normalized to 100% to ease consideration and comparison. The test was administered online through the delivery of separate versions of digitized pdf files over a virtual meeting platform to two successive pandemic-era final semester student cohorts undertaking the Infrastructure Design Project (IDP) course. The duration was prescribed to the process to instill a sense of urgency and limit the potency for manipulation. Invigilation was carried out using continuous live video, brief but intermittent video/audio sessions, or simple digital attendance signing-in/signing-out contingent upon individual student's internet availability-of-service principal at his/her respective locality. The structure of the questions can be divided into two broad categories based on the objectives of this study: the calculation part set at 70% of the marks and the theory part set at only 30%. The former was riddled with pre-determined design parameters with values that had been individually varied so that each student would not receive an identical parameter and be tempted to conspire and collaborate in a test situation. Such governing restrictions would hopefully encourage students to see the futility and difficulty of outsourcing external sources for ready solutions.

Furthermore, allowance was given for independent design decisions by the students for other design aspects to permit inherent complexity in the problem-solving process as transpired by the program accreditation requirements. The variation in parametric values was established through logical and sequential arithmetic steps of increment or decrement facilitated by a computer program. On the other hand, the theory part questions were largely consistent to seemingly facilitate plagiarism, but this apparent downside would be offset by significantly lower marks weightage and the dire circumstances. Digitalized hand-written answer scripts would be returned promptly by the students using the same or any working platform after the prescribed duration by scanning the handwritten scripts and compiling them into a pdf file format. Handwritten measures were insisted and enforced to thwart possible attempts to generate answers by applying pretentious copy-and-paste computer techniques. At this

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juncture, it is worth noting that the enormity of probable solutions was mind-boggling and could not possibly be addressed in the traditional fashion of static answer templates. As such, mechanisation was required and provided using a computer program purposely developed and generic enough to provide context-specific answers on the fly. Platforms ranging from a simple spreadsheet with or without automation to a full-fledged programming language could be deployed. Checks on the program veracity were also carried out by running against successive problem examples with verifiable solutions. Results from the two cohorts were compiled and analysed using statistical software namely SPSS to obtain descriptive parameters and detect inconsistencies.

4. RESULT AND DISCUSSION

The results indicating histograms of marks attainment for successive semesters 1 and 2 superimposed with the derived normal curves are shown in Figures 1 and 2 respectively. In both cases, the frequency tally on both sides of the marks means the value is comparable roughly approaching normal data distribution. In the preceding semester with a higher sample count at 27, the distribution is roughly normally distributed with the mean of 54.33, the median of 53.00, the standard deviation of 11.66, the minimum of 26, and the maximum of 71. Similarly in the succeeding semester, even with the lower sample count of 14 the distribution is also roughly normally distributed with the mean of 48.36, the median of 51.50, the standard deviation of 9.22, the minimum of 34, and the maximum of 59. In both cases, the distribution would be less biased if a greater population or sample count was registered, and other perhaps when assessment contribution was considered as it would have been in the actual academic tally. In any case, the marks were not overly extreme and unnaturally similar as would be initially presumed, and on par with those recorded before the pandemic while in the presence of active invigilation using a similar common test question set. The difference in performance between the semesters was due more to the nature of the problems and disparate grasp on the subject matter rather than devious manipulative efforts.

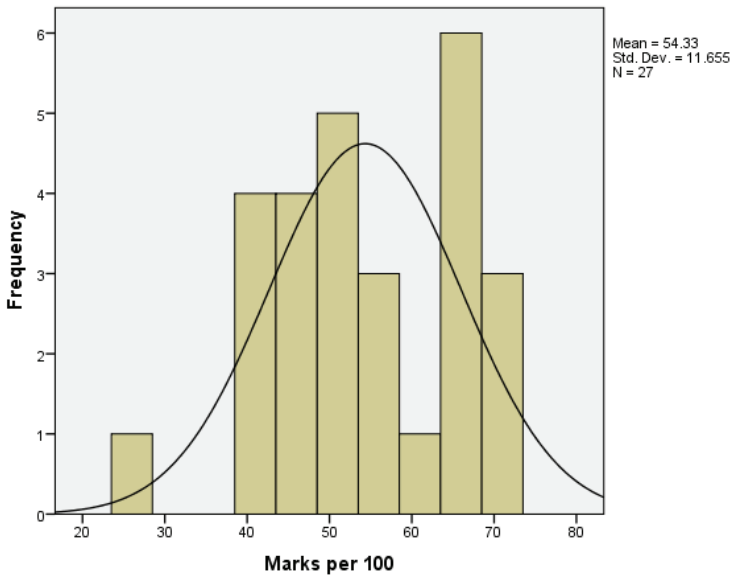

Figure 1: The Histogram of Marks Attainment for Semester 1

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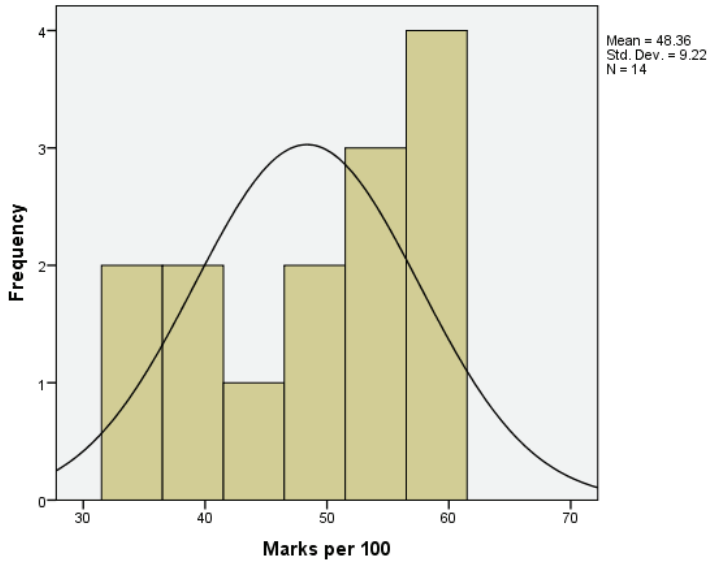

Figure 2: The Histogram of Marks Attainment for Semester 2

Figure 3 depicts the conceptual algorithm used for the development of the computer program to facilitate the generation of context-specific solutions to individually varied and complex problems. It begins with input through manual entry in the appropriate fields and data validation of the design parameter, followed by analysis through a series of predefined processes guided by the relevant design standards to arrive at a design solution. When the generated solutions do not fulfill certain restricting conditions as so highlighted by the program, the preceding steps would need to be iterated beginning with selective input adjustment that would trigger back the design process to arrive at a new solution. Similar checks and iterative procedures would have to be carried out until such time when the resulting alternative solutions become tenable. Then, the required output instance can be generated for the intended academic purposes. You may opt for more case solutions following the program prompt in which the whole steps would need to be replicated and this time with a completely new set of the input parameter to consider and undergoing the same prescribed process. In general, two main characteristics of a well-defined computer program for facilitation of the academic assessment process include:

- Capability to iterate the computational processes until the prescribed restricting conditions are satisfied.
- Capability to replicate the parallel computational processes across multiple possible cases given generating context-specific solutions.

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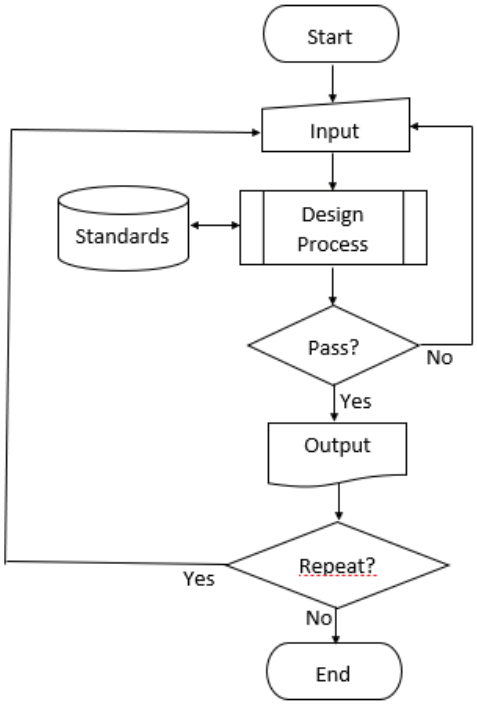

Figure 3: The Conceptual Algorithm of a Versatile Engineering Design Program

Taking a cue from the preceding discussions, the framework for the integration of ICT tools into the online academic assessment process can be developed as illustrated in Figure 4. In essence, when questions are posed by the lecturers the general tendency of the students would be to solicit as such assistance in the problem-solving attempt and thus gain unqualified merit. However, due to the individually varied and complex nature of the problems, the avenue of opportunity would be closed or limited, and students would be left to their own devices and thus likely concede to personal efforts to produce a myriad of solutions in the exigency of the moment. On the flip side, the lecturers would almost be left with the insurmountable task of going through volumes of unfettered scripts saved for the facilitation provided by a pre-developed program that produces context-specific solutions on the fly. The interaction and dynamism of the relationship between the two sides of the role divide will ensure that some form of equilibrium would be achieved over the course of time and circumstances. For example, when students have somewhat managed to solicit ready solutions, this could be detected through the returned scripts using a greater-than-usual degree of similarity or isolated cases of elevated excellence. On the other hand, when the returned scripts have varied greatly from the generated answer templates generated through ICT facilitation, it can be deduced that unjustified questioning difficulty or transmission of information errors have occurred. In both cases, rectification efforts after the fact could be carried out immediately or thereafter for general improvement in the implementation of the academic approach.

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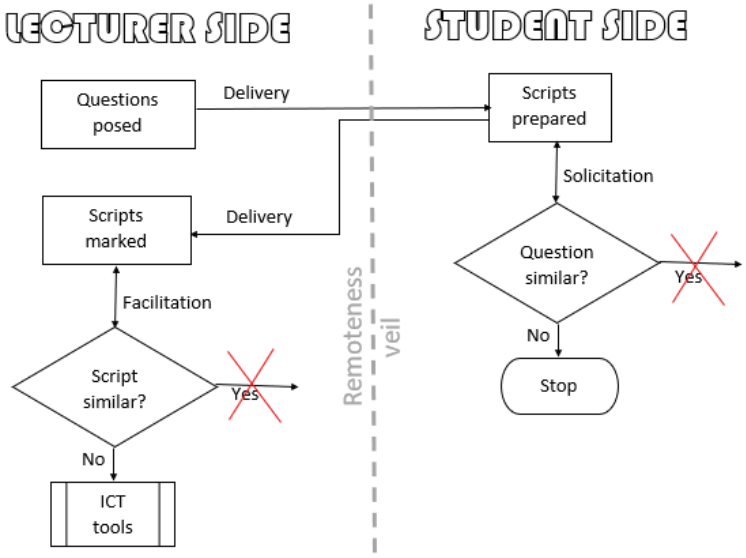

Figure 4: The Framework for the Integration of ICT Tools into the Online Academic Assessment Process

5. CONCLUSION

In conclusion, the objective of ascertaining the validity of the online assessment technique involving individually varied and complex design parameters has been attained. Inherently varied problems and complex could not be easily unraveled through mischievous means but must be addressed through self-learning, competency development, and creativity. However, the problems that would lend easily to such an approach would be calculation types with the parameter that can be individually varied based on certain arithmetic and logical rules and can also be processed by a computer application without significant manual intervention. Text-based theoretical questions on the other hand, although could be randomly selected and posed out of the question bank, are rather highly subjective and opinionated like response especially at the higher level of scholarship. Implementation of facilitation tools for this kind of problem involving ICT tools might be feasible with the current technologies such as artificial intelligence and machine learning but exceedingly complicated to develop and maintain especially for the judgment-prone engineering knowledge and experience where solutions are rarely straightforward and largely context-oriented or may even be diverse subject to predeveloped notion and perspective.

Furthermore, the objective of ascertaining the validity of the pre-developed computer program has also been attained. Two salient characteristics are needed involving iterative and replicative computational processes which must be imbued within such programs to be viable and relevant to the intended outcomes. In addition, the interface must be generic and intuitive enough with data validation and design alert schemes to ensure correct and contextual data entries. Automation of processes through lean encoding economize on system resource utilization by minimizing procedural repetition and promoting common procedure sharing in anticipation of iterative and replicative computational workloads. It would also provide uncluttered input and output interfaces with behind-the-scenes invisible intermediate processes which are not essential in the final output generation.

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Finally, the objective of preparing the framework for the integration of ICT tools into the online academic assessment process has similarly been attained. This approach requires lecturers to prepare assessments characterized by individual variation, contextual complexity, and time exigency from predominantly calculation-based engineering questions. Having closed the avenue of the weakness inherent in identically set questions, it begs to reason that student would inevitably have to resort to personal efforts and endeavour in the preparation of their respective answer scripts. The performance of the two cohorts of students in the pandemic era with attainment comparable to that before the pandemic where active invigilation was possible had testified to this. However, much more research and implementation reporting perhaps under different contexts and circumstances than those prescribed in this paper would have to be carried out to truly gauge the efficacy of this approach in online assessment.

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