Computational Modeling and Assessment of Acceptance Level of Virtual Learning Platforms

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ABSTRACT
One common challenge that comes with postgraduate studies is the fact that students usually have to combine studies with family, job and other personal and professional endeavours. Despite these challenges, the number of postgraduate students has seen massive increase in recent times as a result of job competitiveness and the need for knowledge creation. To cope with the large numbers in postgraduate supervision and to provide flexibility for the working class to acquire higher degrees, online postgraduate supervision has become common. However, research shows that several challenges confront virtual supervision for both the supervisor and the supervisee which include the feeling of isolation and attrition. This paper examines the challenges associated with technologies such as Virtual Learning Platforms (VLPs) for postgraduate supervision and proposes a computational technique for assessing key attributes of VLPs. A survey among 160 postgraduate students shows that students combine a variety of VLPs for communicating with their supervisors for reasons such as cost-effectiveness, technical-know-how and availability of means. The results reveal amalgamated factors that influence the choice of technologies used by supervisors and students. The findings further indicate that user-friendliness, attractiveness, transparency, interactivity and support are reasons why postgraduate students in Ghana mostly prefer social media platforms such as WhatsApp in interacting with their supervisors.

General Terms
Modeling, Computing, E-Learning

Keywords
Virtual Learning, social media, Internet, Technology, Postgraduate supervision, Online Learning

1. INTRODUCTION
Postgraduate degree programmes generally comprise a range of advanced academic degrees awarded by an accredited university or other accredited educational organization. Postgraduate programmes include Postgraduate Diploma, Master and Doctorate Degrees with various captions, requirements and focuses. To obtain a postgraduate degree, the candidate is normally required to conduct original research under supervision by senior academics. Subsequently, there are two key roles involved in the postgraduate degree task accomplishment process viz; the role of the student and the role of the supervisor [15]. The role of the student is to define and execute the various phases of postgraduate research. The supervisor on the other hand is required to oversee and provide good direction to enable the student to accomplish each phase of the research soundly. The details of the working relationship between the supervisor and the student depend on the supervision model adopted and the status of the student; whether full-time, part-time or distance [4],[26]. Full-time candidates would mostly and regularly interact with their supervisors face-to-face whereas part-time and distance students would mostly work with their supervisors through an agreed-upon communication channel. Furthermore, part-time candidates could occasionally arrange for physical meetings with their supervisors, while distance candidates may never get to work with their supervisors face-to-face. Distance and part-time postgraduate programmes have become popular over the years due to the advancement of Information and Communication Technology [17],[22]. By design, distance and part-time postgraduate degree models come with diverse challenges such as cultural, professional, intellectual and personal depending on research supervisor–supervisee interactions and delivery of research activities [25],[36]. Subsequently, several technologies have been developed to support online teaching, learning and supervision in the context of postgraduate degree programmes [17],[22]. Though such technologies are usually designed to meet specific functions of the learning model, certain challenges including technical or socio-emotional could arise as a result of its use [25],[29]. Technical problems arise when there is a failure or a limitation of a sort on the part of the chosen technology. Socio-emotional problems could arise when a candidate feels unconnected because of the wide student to student and student to faculty geographical distance. Despite these challenges, online postgraduate studiesare gaining popularity owing to advancement in ICTs coupled with the emergence of COVID-19 pandemic thereby making it technologically, operationally and economically feasible, particularly in developing countries [3],[29].

In Ghana, many universities are fast adapting to online and distance delivery of education, especially after the emergence of COVID-19 pandemic. However, not much research has been done to ascertain the challenges associated with postgraduate supervision using virtual learning platforms. This study seeks to identify the technological challenges faced by postgraduate students with regards to online supervision and develops a technique suitable for assessing important attributes of Virtual Learning Platforms (VLPs).

2. RELATED WORKS
Online technologies for education delivery have gained high popularity over the past decade due to the high demand for higher education coupled with access to good internet connectivity and related advanced communication technologies [19]. Online learning platforms are built with functionalities such as synchronous audio/video capabilities, interactive whiteboard sharing, application sharing, file exchange, amongst others [13],[18]. It is perceived that online learning has a strong potential of supporting lifelong learning

which can possibly change the long-existing face-to-face mode of knowledge acquisition [9],[12]. Online learning systems have particularly gained significance in recent times due to the outbreak of the COVID-19 pandemic. For instance, with over 188 countries transitioned to online learning months after the emergence of COVID-19 to help curb the spread of the pandemic [3],[24]. As a result, many students are making use of online technological platforms for their studies. Commonly used among such tools include video conferencing systems such as Skype, social media applications, email, mobile phones, learning management systems and content repositories [22],28]. One typical successful implementation of an online postgraduate education delivery platform is reported in [8].

Despite the great opportunities that come with online learning, several challenges accompany it; especially in the specific case of postgraduate supervision. For instance, earlier studies show that online doctoral students may face problems such as intellectual isolation and possibly increase attrition rates depending on their chosen technologies [11],[16].

Online learning strongly depends on the Internet which is in turn made possible by complex communication infrastructure. Any event that can cause a limitation of flow of the Internet connection to the end-user poses technical challenges. Inadequate technology or infrastructure by an Internet Service Provider (ISP) would result in poor internet connection [11],[22],[27]. Other issues include server overload which results in poor connection by the end-user; thereby posing difficulty in accessing online resources [14]. The high cost of data bundles by telecommunication companies also poses lots of challenges to students in many low-income countries [22].

One problem that distance students face is the feeling of lack of physical connectedness. Connectedness, as defined by Hoskins and Goldberg in [37] is "the establishment of a relationship or the failure to do so, with faculty members or fellow students and a judgment of the quality of that relationship". It provides a state in the life of the student where interaction with-like minds in the sharing of knowledge as a means of mutual support is possible. Lack of academic connectedness has been found to pose some level of negative impact on students' progress [5]. Students in the online scenario naturally miss out on this important element of interacting with colleague students and lecturers. Even though such students may be able to share academic material online, they easily miss out on the activities of their departments as compared to their resident counterparts. They do not have any connections with other students who do not share any learning space with them. Furthermore, online students are completely cut out from interacting with other professors who are not their supervisors [11],[25]. Connectedness is necessary for online learning systems as it provides students with a good learning experience and can serve as a significant predictor of students' success or otherwise in distance learning.

Attrition rate in online distance-based doctoral programmes is about 10% to 20% higher than the traditional face-to-face learning model [35]. For example, part-time students are relatively older and have responsibilities such as families and jobs to keep as compared to candidates of traditional doctorates. This situation may lead to divided attention and lack of focus in some cases. Other issues that could frustrate distant doctoral candidates include the slow response from supervisors, lack of mentorship and delayed identification of project topics. Many supervisors have as many resident-doctoral candidates as well as part-time candidates; as a result, supervisors tend to spend more time with resident candidates than non-resident candidates. Negative impacts of attrition include waste of financial and temporal resources of the institution, faculty and students [37].

Postgraduate policies and internet-driven technology have been proposed as a way of increasing connectedness in online doctorate settings.Improving connectedness using systems that enhances social interactivity, collaborative work and knowledge or resource sharing potentially could reduce attrition. Several studies such as [6],[31],[34] have shown that well-tested internet technologies such as social media platforms, web-based communication technologies (e.g., Skype) and collaborative working platforms (e.g., Microsoft Share Point) can help to improve connectedness. Even though physical connectedness is needed for good academic progress and success, interaction beyond the classroom is very instrumental in building connectedness. One way of building connectedness outside of the classroom is using social media platforms and web communication platforms. Research indicates there is a strong connection between connectedness and persistence for online doctoral students [6],[35]. Social networking and web-based communication technologies are instruments of persistence in the online doctoral research scenario. Share-point is particularly useful at the dissertation and proposal development stages. It allows both supervisor and student to collaboratively edit and make well-tracked changes to research work from time to time until completion.

To improve connectedness and reduce attrition, many universities choose to design blended doctoral programmes in place of fully distance programmes. The blended programmes allow students to execute specified aspects of their work as residents and other aspects as non-residents [33]. The common model is to allow students to develop the proposal and literature study from a distance and the rest of the project as resident students. There exist other models, where students are required to meet their supervisors from time to time to complete specified aspects of the work.

3. METHODS AND RESOURCES

3.1 Data Collection

The study sought to assess attributes such as user-friendliness, attractiveness, transparency, interactivity, and support of selected virtual learning platforms in the context of online postgraduate supervision. These attributes were selected in line with the findings of Maor et. al [22] who arguethat, a good virtual learning platform should be user-friendly, transparent, attractive to students and supervisors and capable of providing learners interactivity and support for each other. Guided by Olivier et al. [28], the selected virtual platforms are:

(i) Social Media (WhatsApp/Facebook)/ Telegram etc.);

(ii) Traditional Phone Calls;

(iii) Conferencing Platforms (Skype/Zoom/Google Classroom/Webex etc);

(iv) Dedicated Online Learning Platforms (Moodle, etc);

This study collected data through the administration of questionnaires with a likert scale and other closed-ended questions. The questions required respondents to indicate their assessment of levels of user friendliness, attractiveness, transparency, interactivity, and support for the four virtual platforms. A Google form was used in developing the questionnaires and administered to postgraduate students in three Ghanaian universities through personal contacts and snowballing. In all, one hundred and ninety-seven respondents

filled the form. All incomplete forms were considered invalid and therefore excluded from the study. The final dataset used for this analysis represented responses of one hundred and sixty postgraduate students offering various postgraduate programmes in three Ghanian universities. The data was then downloaded as an MS Excel sheet and analysed.

3.2 Data Analysis

The analysis show that, 62.5% of the respondents were pursuing Master degrees (MSc/MPhil) while 37.5% were PhD candidates. The majority of the respondents (75%) were within the age group of 26 to 35 while the rest were within the age group of 36 to 45. Respondents indicated a variety of combinations of technologies that facilitate their interaction with their supervisors. 31.5% indicated a combination of the traditional phone calls and social media platforms as a means of communication between them and their supervisors. Another 31.5% of respondents mentioned a triad combination of traditional phone calls, social media (WhatsApp, Facebook, Twitter, Instagram etc.) and video conferencing platforms (Skype, Zoom, Google Classroom, Webex etc) as the main technologies used to suit their interaction with supervisors. There was also a good number of respondents (25%) who were satisfied with using only video conferencing platforms (Skype, Zoom, Google Classroom, Webex etc). A small minority (6.25%) also reported the following distinct combinations of technologies for the studies: Combination of social media (WhatsApp, Facebook, Twitter etc.), video conferencing platforms (Skype, zoom etc) and dedicated online learning platforms (Moodle, etc) systems. The other is the combination of social media (WhatsApp/Facebook)/Telegram etc.), video conferencing platforms (Skype/Zoom/Google Classroom/Webex etc). The data reveals that most (93.75%) postgraduate students use a combination of technologies and choose technologies tailored to their needs based on affordability. Also, knowledge of the use of a particular technology informs their choice of supervisor or student. Other reasons given include user-friendliness and easy interactivity with peers for knowledge co-creation.

In their quest to gain effective supervision from their supervisors, the respondents shared various combinations of challenges they face. Unstable or poor internet connectivity was identified as a major challenge for 50% of the respondents. Some respondents (26.25%) also mentioned that a combination of factors such as poor internet connectivity, lack of conducive environment at home and high cost of internet bundles acted as barriers to their study. Other respondents (18.75%) stated they had so far, no challenges with their supervision online.

3.3 Data Modeling

The analysis focused on assessing each chosen platform in terms of the five attributes. For each platform, the responses on each attribute were reorganised into either positive or negative for various categories of questions as follows:

(1) Questions where the possible responses are "yes" or no: Total responses for "yes" was labelled positive while that of "no" was labelled negative.

(2) Questions where the possible responses are Excellent, Good or poor: The total number of respondents for "Excellent" and "Good" were summed together as positive, and that of "poor" was labelled negative.

(3) Questions where the possible responses are High, Low, or very low: The total number of respondents for "High" was labelled as positive, and that of "Low" and "Very Low" was summed and labelled negative.

The total positive responsesis therefore, the sum of respondents who answered "Yes", "Excellent", Good" and "High". while the total Negative response is the sum of respondents who answered "No", "Poor", Low" and "Very Low" for an attribute. Table 1 shows a sample of the data obtained after the reorganization.

Table 1. Sample of the Reorganised Data

Virtual Learning Platform (VLP)	Transparency	
	Positive	Negative
Social Media	150	0
Traditional Phone Calls	60	110
Video Conferencing Platforms	120	0
Dedicated Learning Platforms	80	10

We denote the total positive and negative responses of an attribute ***a*** in relation to a given Virtual Learning Platform (VLP), p as R_a^p and N_a^p respectively. The total positive responses R^+, of an attribute ***a*** in relation to nVLPs can therefore be given as:

$$R^+ = \sum_{i=1}^{n} R_a^{p_i} \qquad (1)$$

The total negative responses R^-, of an attribute, a in relation to n VLPs is analogically given as:

$$R^- = \sum_{i=1}^{n} N_a^{p_i} \qquad (2)$$

We then assess users' degree of acceptance, a^+ of each VLP per attribute as the ratio of the total number of positive responses of an attribute for a given VLP to the Arithmetic mean of all positive responses across all VLPs for that attribute.

$$a^+ = \frac{nR_a^p}{\sum_{i=1}^{n} R_a^{p_i}} \qquad (3)$$

Analogically, we assess users' degree of displeasure, a^- as shown in equation 4.

$$a^- = \frac{nN_a^p}{\sum_{i=1}^{n} N_a^{p_i}} \qquad (4)$$

Equations 3 and 4 allow assessment of the VLPs in terms of the average negative or positive responses respectively per attribute.

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3.4 Implementation and Evaluation

The technique described in section 3.3 was implemented in C++ according to the pseudocode below:

```
Start
     Initialize
     PositiveResponses[m][n]
```

```
      Initialize
      NegativeResponses[m][n]
      Initialize sumPosCol=0;
      Initialize sumNegCol=0;
      Initialize PositiveRespAvg[n];
      Initialize NegativeRespAvg[n];
      Loop from i=1 to m
      Begin
         Loop from j=1 to n
           Begin
            sumPosCol=sumPosCol+Posit
            iveResp[j][i];
      sumNegCol=sumNegCol+
      NegativeResp[j][i];
           end
      PosAvg=sumPosCol/n;
      NegAvg=sumNegCol/n;
      PositiveRespAvg[i=
      PosAvg;
      NegativeRespAvg[i=NegAvg;
      sumPosCol=0;
      PosAvg=0;
      sumNegCol=0;
      NegAvg=0;
End
      Loop from i=1 to m
      Begin
      Loop from j=1 to n
          Begin
            Print PositiveResp[j][i]/
      PositiveRespAvg[i]
            Print NegativeResp[j][i]/
      NegativeRespAvg[i]
          end
      end
End
```

Every line of the programme as shown in the pseudocode can be executed in constant or linear time, except those with the nested loops (highlighted in grey) which is executed in quadratic time. The complexity of the proposed technique is therefore $O(n)^2$.

4. RESULTS AND DISCUSSION

In essence, equations 3 and 4 allow to weigh the attributes of each Virtual Learning Platform (VLPs) by comparing the number of the positive and negative responses of each attribute for the given VLP to the means of positive and negative responses respectively of all VLPs with respect to that attribute. Hence, for each VLP, we analyse whether it weighs above or below the mean in terms of each attribute. The outputs of equation 3 (a^+) and that of equation 4 (a^-) are shown in table 2.The results show that social media received the most positive endorsements across all attributes. In terms of "Interactivity" however, it received very high negative comments. "Traditional Phone Calls" also score above the mean responses in four out of the five attributes under consideration. Its transparency however received the most negative amongst all the attributes. This is an indication that most postgraduate students consider traditional phone calls and social media platforms as common tools used for online supervisor/supervisee interactions. These findings resonate well with those of Olivier et. al, [28] and Maor and Currie, [22] who found that postgraduate supervisors in Australia often use social media networks and phone calls to interact with their students.

It is further observed from table 2 that, though "Video Conferencing Platforms" was weighted above average in only three out of the five attributes, it never received negative ratings above the mean negative comments in any attribute. This is also an indication of a very high level of acceptance for postgraduate supervision.

Finally, the worst-rated by table 2 is "Dedicated Learning Platforms" which weighs above the mean positive responses only in the case of "Interactivity". The finding also shows that it has a very poor support base. Social media, Traditional Phone Calls and Video Conferencing Platforms are, therefore, the most widely used for postgraduate supervision. This reflects the observation from the collected data that, 31.5% of respondents mentioned a triad combination of traditional phone calls, social media (WhatsApp/Facebook)/Telegram etc.) and video conferencing platforms (Skype/Zoom/Google Classroom/Webex etc) as the main technologies used to suit their supervisor/supervisee interactions. These are coherent with findings by Kentnor [17] and Rambe and Mkono [30] who argued that in a resource-constrained environment such as those of developing countries, combining technologies helps to sustain supervisor-student interaction. Technological tools, therefore, play a critical role in maintaining good supervisor/supervisee communication for distance postgraduate students. So, the use of available communication tools plays a critical role in solving the challenge of maintaining good and effective interactive supervisor/supervisee communication.

As a result, most respondents in this study combined a variety of technologies to facilitate interactions with their supervisors. These findings reflect earlier studies by Watts, 2008 [36] and Maor and Currie, 2017 [22] that reported how the use of technology plays a significant role in supervisors-supervisees interaction.However, factors such as the cost associated with the technologies, their availability and user-friendliness amongst others are determinants of their adoption for remote supervision.

Table 2. Assessment of VLPs

	User Friendliness		**Attractiveness**		**Transparency**		**Interactivity**		**Support**	
	a^+	a^-	a^+	a^-	a^+	a^-	a^+	a^-	a^+	a^-
Social Media	1.21	0.00	1.20	0.00	1.46	0.00	1.09	1.71	1.33	0.50
Traditional Phone Calls	1.21	0.00	1.20	0.00	0.59	3.67	1.27	0.57	1.44	0.75
Video Conferencing Platforms	0.91	0.00	0.96	0.00	1.17	0.00	1.00	0.57	1.00	0.75
Dedicated Learning Platforms	0.68	0.00	0.64	0.00	0.78	0.33	0.64	1.14	0.22	2.00

These findings confirmed previous studies by Hoskins and Goldberg 2005 [37] and Deshpande 2016 [11] who reported that though, technology is a beneficial tool, it can also become a tool of exclusion in online learning.

5. CONCLUSION AND FUTURE SCOPE

The research has shown that postgraduate students use a combined variety of technologies to facilitate interactions with their supervisors. It is evident from this study that, there were various combinations of challenges faced by the postgraduate students in connection with the usage of available technologies to communicate with their supervisors. Poor internet connectivity and the high cost of internet bundles were some of the major challenges identified that could directly be attributed to being a problem from the telecommunication companies in Ghana. There was also the problem of lack of conducive environment at home to use these technologies by the students to interact with their supervisors and this could directly be problems solely attributed to the postgraduate students. It is therefore recommended supervisors and postgraduate students continue to explore diverse technologies especially with low bandwidth requirements to foster effective yet affordable communications to directly improve the quality of postgraduate supervision.

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