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Enabling Authentic Activities for Effective Collaboration in Remote Access Laboratories

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Abstract The online learning challenge is one of the most significant issues addressed and raised these days. Especially during the emergence of the Covid19 pandemic and the consequent changes in online learning, particularly the practical courses. This study indicates that to apply the traditional Doolittle Principles which has developed eleven principles to support collaboration in a face-to-face classroom, to online learning. The collaboration is an interactive process that engages two or more participants working together to achieve educational outcomes they could not accomplish independently. These principles will be used on the study in remote access laboratories by participating two or more participants in a remote laboratory experiment from different locations, where the remote laboratories can define as a class of online learning systems that provide access to laboratory infrastructure and learning environments through the Internet. This instructional guideline will be developed and trialled in order to address this aspect. As a result, Doolittle principles can be applied theoretically in the context of online learning activities to support the Remote Access Laboratories (RAL) activity.

Keywords: activities Remote Access Laboratories, online collaboration, learning environments, authentic.

إتاحة عامل الأنشطة أصيلة في إطار التعاون الفعال في مجال المعامل التي تستخدم الأتصال عن بعد

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الملخص يعد تحدي التعلم عبر عن بعد من أهم القضايا التي تمت معالجتها وإثارتها في هذه الأيام. خاصة أثناء ظهور جائحة Covid19 والتغيرات الناتجة في التعلم عبر عن بعد ، وخاصة الدروس العملية. تشير هذه الدراسة إلى أنه لتطبيق مبادئ دوليتل (Doolittle) التقليدي والذي من خلاله تم تطوير أحد عشر مبدأ لدعم مبدأ التعاون في الفصول الدراسية التقليدية والتي تعتمد التدريس وجها لوجه ، على التعلم عن بعد. التعاون هو عملية تفاعلية تعتمد علي مشاركة مشاركين أو أكثر يعملون معاً لتحقيق نتائج تعليمية لم يتمكنوا من تحقيقها بشكل مستقل. سيتم استخدام هذه المبادئ في الدراسة في المعامل التي تعتمد تقنية الوصول عن بعد من خلال مشاركة اثنين أو أكثر من المشاركين في تجربة المختبر عن بعد من مواقع مختلفة ، حيث يمكن للمعامل أو المختبرات البعيدة تعريفها على أنها فئة من أنظمة التعلم عبر الإنترنت والتي توفر الوصول إلى البنية التحتية للمختبر وبيئات التعلم من خلال الأنترنت. سيتم تطوير هذا الدليل التعليمي وتجربته من أجل معالجة هذا الجانب. ونتيجة لذلك ، يمكن تطبيق مبادئ دوليتل (Doolittle) نظرياً في سياق أنشطة التعلم عن بعد لدعم نشاط مختبرات الوصول عن بُعد (RAL).

الكلمات المفتاحية: نشاطات المعامل عن بعد، التعاون عن بعد، بيئة التعلم، أصيلة.

Introduction

Laboratory work plays an essential role in education, particularly in the fields of science and engineering. Remote laboratories are a class of online control systems that provide access to laboratory infrastructure and learning environments through an interface provided on the Internet. In recent years, an extended effort has resulted in a number of users being able to access equipment from anywhere at any time that suits them [1, 2].

Remote laboratories eliminate the need for the physical presence of students in the laboratory and, hence, offer a variety of logistical and economic advantages over traditional co-located laboratories. Remote laboratories not only supplement traditional laboratories without remote access but can enable new learning opportunities for students. For example, students who are located in different countries can perform experiments together, thereby enhancing the participants' intercultural capability [3, 4].

Collaboration is an interactive process that engages two or more participants working together to achieve educational outcomes they could not accomplish independently. In a collaborative learning environment, students become involved in a common outcome where they depend on and are accountable to each other. In [5, 6] the authors have confirmed a long-held belief that peer collaboration can play a key role in positively influencing the outcomes of student learning. Collaborative e-learning encompasses constructing knowledge; negotiating meanings; and/or solving problems through the mutual engagement of two or more learners in a coordinated effort using the Internet and electronic communications for some, or all, of their interaction [7].

However, while the majority of traditional laboratory exercises are group-based, which implies some form of collaboration, a vast majority of the current remote laboratories provide only limited support for collaboration [8, 9]. While the traditional laboratory may provide an opportunity for collaboration, learning benefits may not be achieved since working or learning in groups might be for logistical rather than pedagogical reasons [8, 9]. Collaboration can lead to increased quality of peer interaction, mastery of subject matter content, and decrease anxiety levels—and could well lead to better attitudes toward science laboratory education [10]. Therefore, it is important to investigate ways to support collaborative learning in remote laboratories.

Different types of laboratories (such as hands-on, simulation, and remote laboratories) are influenced by how students effectively work together. Lowe, Berry [11] note that the main problem facing collaboration in remote laboratories is the very limited scope for collaboration among students in different geographic locations. Previous studies such as those of Huang [12], Nafalski, Nedić [13], Nedić and Nafalski [14] confirm these obstructions and have identified that few remote laboratories offer a collaborative working environment. Few remote laboratories offer a collaborative learning environment because the activities are not designed for collaboration; plus the systems do not support collaboration—despite the increasing demand from universities worldwide [14]. The importance of collaboration in learning is particularly visible when it is done well by combining the efforts and strengths of the individuals who are collaborating [15]. Typically, collaboration provides opportunities to improve learning outcomes.

This research aims to demonstrate that the principles of Doolittle's research is appropriate and can be adapted to suggest suitable development of online laboratories that support and encourage collaboration. These principles can be modified for RAL and then trialled and evaluated.

Literature Review

Laboratories are widely used in science and engineering education and are of critical importance as a conduit between the theory and practice of scientific phenomena. Collaboration in remote access laboratories allows students to perform practical experiments remotely in a collaborative way and to engage with other students. Much of the research on collaboration draws on social constructivist learning theories on collaborative and cooperative learning which is rooted in the work of Piaget and Vygotsky. This research will build on the social constructivism theory that underpins social learning where learning happens through active engagement and where students need to work in groups to construct knowledge.

Collaborative laboratories

This type of collaboration is seen as an effective approach to improving and supporting educational outcomes [16, 17]. People generate knowledge and meaning when they share their ideas and experiences, as well as gaining benefit from social interaction. Another benefit is the increase in motivation stemming from effective learning in a collaborative environment. This approach has already demonstrated a positive effect on students in laboratory sessions [18].

Furthermore, collaborative activity enables students and teachers to discuss findings which may be flawed and students can then correct any errors [19]. Moreover, a remote laboratory environment provides collaboration capability between peers (student-to-student communication and student-to-teacher communication) that make the experiment easier to conduct and understand. Laboratory works via remote collaboration can play a vital role in learning. Notwithstanding the progress already made in the traditional (hands-on) laboratory and based on teamwork, it has lacked the features of collaboration offered by remote laboratories [20, 21].

Effective teamwork is one of the most important aspects of engineering and science courses. Students in remote laboratories who are learning good collaboration skills with other national and international students enhance their prospects for professional employment in the international market, because the remote laboratory is an excellent platform for collaboration and networking [22]. Lab-share projects demonstrate that remote laboratories can be expanded or extended worldwide to thousands of students[23]. The collaborative approach is an added advantage to the remote laboratory and an improvement over the hands-on and simulation laboratory as interaction is easier in remote access laboratories than face-to-face and this aspect is seen as an important characteristic of the profession into the future [22].

Collaboration in a remote access laboratory: theoretical framework

Several theories have been offered to demonstrate how working collaboratively has become acceptable in learning—the idea being that students need to work with their peers for enhanced learning outcomes. Spronken-Smith [24] and Montiel-Overall [25] point out that much of the research on collaboration draws on social constructivist learning theories on collaborative and cooperative learning which is rooted in the work of Piaget and Vygotsky; and also stems from several learning theorists including Dewey and Bruner. The foundation of their theories is that learning is active, and knowledge is constructed through interaction. Vygotsky points out that building on the constructivist realms underpins social learning where learning happens through active engagement. The idea is that students need to work in groups to construct knowledge. Verenikina [26] believes that if Vygotsky is correct and students develop in social or group settings, the use of technology to connect rather than separate students from one another will lead to higher performance. In addition, one of the Vygotskian classroom principles is that learning and development is a social, collaborative activity. Hence, collaborative learning is important in constructing knowledge.

Vygotsky's work focuses on the value of social collaboration, which causes individual cognitive change as opposed to being merely stimulated by it [27]. Similar to the views of Piaget, Vygotsky emphasized the importance of mixed groups of collaborators [28]. Vygotsky describes the zone of proximal development (ZPD) as The distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under students' guidance or in collaboration with more capable peers [29].

Contrastingly, Piagetian studies typically pair students from different developmental stages to facilitate cognitive conflict—studies in the Vygotskian tradition normally pair individuals with others which means that they are in a collaboration mechanism. Rather than focusing on cognitive conflict as a trigger for conceptual change, social constructivism views collaborative learning as learning that occurs within the zone of proximal development [28]. Collaborative learning is particularly accrued when students need help from peers, which means that the social constructivism (zone of proximal development) of Vygotskian theory is working better with collaborative learning than with Piagetian theory. The theory that underpins social constructivism is Vygotskian social constructivist theory and it has emerged to fill the gap created in collaboration inherent in social constructivism and can provide the theoretical underpinning to support the use of collaborative research frameworks such as collaboration in a remote access laboratory for aiding student development.

The theory that comes from constructivism emphasizes the other peer (student) in the role of individual knowledge building, with particular emphasis on conflict and individual growth and social development. This theory emphasizes fruitful exchanges between individuals, and progress made through social interactions is determined by the individual; and also helps interaction on the cognitive structure of individual growth and development continuously [30].

This approach confirms that all group behaviour is more than just the sum of the individual parts. In other words, the interaction within groups will develop in ways that cannot necessarily be predicted based on contributions from members of the group. This suggests that the latter vision displays more than individual members of groups; and the unit of analysis will produce a different point of qualitative conclusions about collaboration [27].

Doolittle principles.

Doolittle principles are a significant component of this study. He developed 11 principles to support collaboration in a face-to-face classroom, those principles will be identified and applied in the context of remote access laboratories. [31]Doolittle (1995) has previously synthesized the work of several social constructivism theories to produce 11 recommendations:

1. Teach using whole and authentic activities.
2. Create a 'need' for what is to be learned.
3. Create classroom exercises that require social interaction with peers, parents, teachers, or professionals.
4. Encourage self-talk or egocentric speech.
5. Provide opportunities for verbal interactions.
6. Closely monitor student progress in order to avoid assigning tasks that are not within a student's zone of proximal development.
7. Instruction or activities must precede a student's development.
8. Present tasks that students can perform successfully with assistance.
9. Provide sufficient support to enable the student to perform challenging tasks successfully, and then gradually withdraw support as the student becomes more skilled.
10. Students must be given the opportunity to demonstrate learning independent of others.
11. Construct activities that are designed to stimulate both behavioural changes and meet cognitive changes.

Social constructivism theory in this study can benefit a student's development via assistance from more expert peers—providing they adjust the help they provide to fit the less mature students' ZPD. According to this theory, the study will expand on research relating to collaboration in an on the online environment.

Research Methodology

The key research question of the project focuses on enabling authentic activities for effective collaboration in remote access laboratories. As such, this study will develop the components of the instructional framework and the environmental requirements for the facilitation of remote collaboration. This paper focuses on the identification of an existing theoretical framework for collaboration and its potential for application in remote laboratories. The literature review provides the foundation for this study and covers both collaborative learning and remote access laboratories. [31]Doolittle's (1995) principles for facilitating collaboration in face-to-face environments will be used to developed principles for remote collaboration on the context of remote laboratories. Those principles will form the basis for the remainder of the study.

The researcher has selected one of Doolittle's principles as an example to show how the principles will be modified to an online environment This is the first draft of the researcher's evaluation of Doolittle first principle to make it relevant to RAL environment. Making the activity authentic or situating it in the real world is an aspect needs to occur in collaboration. The researcher will choose some of the Doolittle principles as examples in the methodology. Selecting the learning activity and devolving it as an authentic activity will reveal evidence of authentic activity, or will be modified to render it authentic. This is an example of how to teach authentic and well-design activities, and these aspects can serve as a list of useful guidelines [32](Reeves, Herrington & Oliver 2002) that can be used to demonstrate the authenticity of the remote access laboratory.

This methodology for developing guidelines that support collaboration in a remote access laboratory (RAL) environment is the most appropriate for this investigation and was chosen in order to test the new guidelines for online collaboration within specific learning activities. It will enable the researcher to understand the complexity of collaborative learning activities and will use multiple sources of evidence. The use of case studies to investigate collaboration in remote access laboratories in-depth is particularly appropriate, as described by Patton [33]. The qualitative investigation typically focuses in-depth on rather small samples, even single cases, selected purposefully. A feature of case study research is the use of multiple data sources—a strategy which also enhances data reliability. The case study is appropriate for this study because the research will be guided by case study as described by Yin [34]; data collection and analysis will be guided by [35]Kagan's (1992) elements of collaboration which are grounded in social constructivism theory, and the case study benefits from the prior development of theoretical propositions to guide data collection and analysis.

Enabling Authentic Activities in RAL

This was the first principle for evaluation and Doolittle's first principle made it relevant to a RAL environment. To make activity authentic or situate students in the real world is an aspect that needs to occur in collaboration. Some of Doolittle's principles have been chosen as examples in the methodology. Specifically, as espoused by Doolittle, it involves selecting the learning activity and devolving it as an authentic activity and keeping a checklist as evidence of authentic activity and, if necessary, determines what modifications are required to make it authentic. This provides an example of how to teach authentically and design activities, and these properties can elicit a list of useful guidelines [36] to demonstrate authenticity in a remote access laboratory:

1. Authentic activities have real-world relevance, matching as nearly as possible the tasks of professionals in practice. [37-43].

The researcher will use the conference tool (collaboration tool) to develop a practical activity, making regular adjustments based on student feedback and observations of activity in a remote laboratory. The activity will be designed to encourage ways of thinking that would be expected in the real-world management of experimental components. Using the conference tool will enable us to plan the learning methods and modify variables at each stage of the activity

2. Authentic activities are ill-defined, requiring students to define the tasks and sub-tasks needed to complete the activity, problems are open to multiple interpretations rather than easily solved by the application of existing algorithms [37, 40, 42-47].

The activities will be complex; requiring students to find associations between variables that will be not explicitly linked. They will need to derive their research questions after identifying gaps in their knowledge and understanding, conduct the research and then create their notes in conference tool, summarizing and synthesising the information they will find.

3. Authentic activities comprise complex tasks to be investigated by students over a sustained period of time [37, 41, 43, 48].

Each activity will run a week period, with students and the researcher meeting on an online and interaction on conference tool will be used to supplement the online collaboration discussions. The task (practical activity) will be not an isolated activity, with conference tool will use both in a remote laboratory while students will engage in research and content creation, and the researcher and peers will give feedback on the students' conference tool to take note.

4. Authentic activities provide the opportunity for students to examine the task from different theoretical and practical perspectives, using a variety of resources that require them to critically evaluate information [41, 43, 44, 48].

The researcher will review students' activity notes daily, providing feedback using the comments feature, asking questions about missing information, unsubstantial claims and dubious sources. Students will able to respond to the comments, asking their questions or clarifying their understanding. Other researchers will join in the conversation, sharing their own experiences and thoughts.

5. Authentic activities provide the opportunity to group working [37, 46, 49].

Activity notes will develop collaboratively by the student groups, and all notes will be available to all other groups, as well as to researcher. Each day, students will create summaries of their activity using the slideshow component of conference tool, presenting this in a laboratory, and then will share the summary with everyone. Conference tool also features an instant messenger, which will allow students and staff to discuss aspects of the activity notes while looking at the document together, from different locations.

6. Authentic activities provide the opportunity to reflect on learning, both individually and with others [45, 46, 48-50].

The researcher will provide feedback to students within their activity notes in the form of comments and questions, encouraging them to reflect on their assumptions and reasoning. Students will be challenged on their statements and encouraged to articulate their understanding, as the questions will be not asked to elicit information, but rather to stimulate further thinking.

7. Authentic activities can be integrated and applied across different subject areas and lead beyond domain-specific outcomes [41, 45, 48].

Each activity will be designed to integrate research, ethical reflection and knowledge from other modules, e.g., Anatomy. The activity will be designed so that it will be not an isolated activity that will be separate from other modules.

8. Authentic activities are seamlessly integrated with the assessment [46, 51-53].
Formative assessment will be an inherent part of the activity, with peers and researcher regularly challenging statements and assumptions that arose during the classroom sessions, and in the online notes. Students and the researcher will use comments in the conference tool to ask questions regularly.
9. Authentic activities create polished products valuable in their own right rather than as preparation for something else [49, 54].
The notes that will create in conference tool constitute the students' content for the module, making them an important product of the task. The questions for the tests at the end of each term will be derived from both the students' notes and the researcher' guides, which meant that the student notes have real value.
10. Authentic activities allow competing solutions and diversity of outcome [45, 48, 55-57].
Each group's online activity notes will be different, reflecting the questions to be answered after exploring their understanding of the activity. The researcher will ensure that the major concepts will be addressed, however, students could take their routes to achieve the objectives.
Facilitating collaboration in a face-to-face mode as described by Doolittle's (1995) constructivist principles will be used as a base for the process. This will be followed by the formulation of theoretical principles which form the structure for the remainder of the study. The research will develop and document a proposed framework to guide collaborative learning in an online environment for a specific online learning activity.

Conclusion

The research will focus specifically on Evaluation and modification of Doolittle's principles and made it relevant to a RAL environment. However, it could be extended to collaboration online generally. Laboratory teaching is relevant from high school to university. Limited access to laboratory equipment, as well as improving collaboration in an online laboratory, can enhance learning outcomes; and online collaboration will be a feature of future teaching in an online environment.
This work shows that the classroom-based principles of Doolittle can be adapted to formulate the suitable development of online laboratories that support and encourage collaboration.
Those principles will be tested on case study methodology, whilst not having been applied completely to Doolittle's principles, has been applied to authentic learning, showing that the methodology is suitable and will result in a testable framework.

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