Exploring the Effectiveness of Student-generated Video Tutorials in Electronic Lab-based Teaching

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***Abstract*—Lab-based teaching in which hands-on experiments are to be conducted by students takes an important part for a wide range of engineering and science disciplines. In our current practice, the lab-based teaching involves live demonstration and tutorials after the off-line lab manual review. This has become particularly problematic when the number of students is large and insufficiency on the lab-supporting system becomes a common issue. In the meantime, even with a small number of students, it can be interesting to prepare the lab in a one-to-one tutorial. Well-designed video tutorials eliminate the time and space constraints on learning and provide comprehensive details to students to enable them focus on deepening the understanding of concepts, rather than spending majority of time on trouble shooting during the lab.**

With the full technical support from the Digital Learning Resources Hub at Xi'an Jiaotong-Liverpool University, we propose to involve student volunteers to generate a series of customized video tutorials for our electronics lab-based teaching practice. From the viewpoint of students themselves, these video tutorials are carefully designed based on students' learning needs to seamlessly integrate a wide range of theoretical and practical information. Under the supervision of staff, volunteers will be able to repeat their learning cycles with a different role and enhance their own understanding and knowledge structures, promoting the student-centered education model. Some scenery-based video tutorials will be used in the online quizzes questions to better prepare the students. The generated video tutorials will be shared across a number of electronic engineering modules to further investigate the effectiveness of these video tutorials. The effectiveness can be further explored using online questionnaires and online quizzes and evaluated by comparative studies.

I. Introduction and Literature review

Video tutorials play more important roles along with the consistent development of the approach of "Flipped Classroom" in engineering education [1]–[4]. In a filpped classroom, learning contents are delivered through video tutorials outside of classroom so that time can be saved for more student-centred activities [5]. As a critical part in engineering courses, lab-based teaching cultivate a unique-learning environment to enhance students' understanding on key concepts [6]. Considering its practice-oriented and project-based features, lab-based teaching can be a flipped type of teaching where the majority of teaching contents could be provided outside the lab and students take the leading role in learning via hands-on experiments supported by instructors. In a traditional lab-based teaching practice, it usually involves live demonstrations from the instructors and lab manuals to be studied before the lab. Hands-on experiments are to be conducted by students afterwards.

Similar studies have been done in the past by a number of educators and researchers. Fortino *et al.* proposes to use a series of video tutorials to enhance laboratory learning in biomedical engineering [7]. In their practice, video tutorials provided extra resources for students to understand the knowledge of equipment used in the lab and support students to spend the precious lab time in deepening conceptual knowledge. However, authors have not mentioned how to encourage students to actually watch the videos. Khalid proposed to apply student-generated videos to enhance teaching quality in Aerospace Engineering class [8]. In this paper, Khalid demonstrated that video generations enable students to repeat learning cycle and in turn benefit students in learning effect. Alonso *et al.* took a similar trial in using videos to enhance laboratory for organic chemistry [9]. These videos were used to demonstrate the most important parts of experiments using a variety of video playing techniques. The effectiveness of the video is not discussed and measures to encourage students to exploit the video are not mentioned in the paper.

In the traditional lab-based learning method, there are a number of issues in effectively conveying the information.

- Too much information needs to be provided in the lab manual to get students well instructed.
- Effect of the live lab demonstration may heavily rely on many factors such as the competence of demonstrator, conditions of lab rooms and number of students.
- Students tend to forget or miss out important information during the experiment without reusable resources to refer back to.

In this paper, we introduce student-generated video tutorials to enhance the information conveying during the lab-based teaching [10]. Online quizzes are applied to encourage students to effectively explore these videos [11]. Compared with a large number of existing online video resources, the video tutorials will be carefully designed based on students' learning needs during the experiments from student's own perspective. Under the direct and close technical supervisions from lab technicians and academic staff, with full technical support from university education professional support team, these video tutorials are generated with high quality and designed to

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seamlessly integrate a wide range of theoretical and practical information, which provide one-to-one tutorials and promote active learning with online assessments and greatly enhance the efficiency during lab experiments. Generated videos are to be shared across university wide platform to further exploit the benefits of these video resources.

II. Project Implementation

A flow chart for the project execution is shown in Fig. 1.

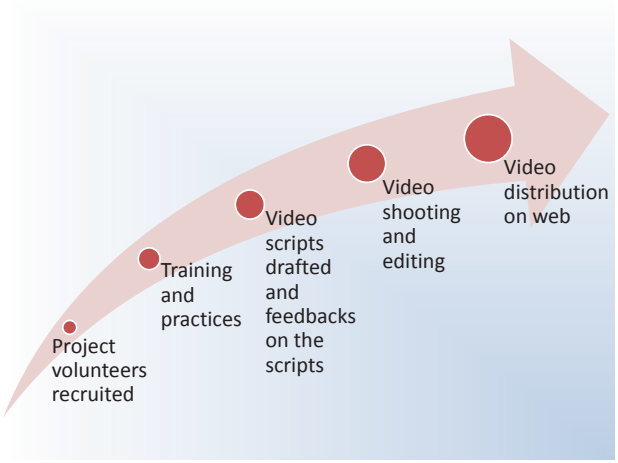


Fig. 1. Project execution flow chart

A project manager is recruited from senior students to help support the entire project and it turned out to be an effective method to manage the team. The manager will support the project in terms of organizing the training sessions for volunteers and promptly reporting issues during the project to staff. In the meantime, student volunteers who participate in the project are selected from year-two students. Most of these volunteers have experiences in conducting experiment using lab instruments, such as oscilloscope and multimeter etc. Similar previous experiences motivate the student volunteers to join this project and devote themselves with efforts and dedications since this project is supposed to enhance their understanding and skills on using the lab instruments and to improve their confidence to stand out among their peers as the small teachers. In addition, student volunteers are most familiar with the most frequently asked problems during the lab and the tutorials can be better designed based on students' previous learning experiences.

Project participants could be well awarded with these special extracurricular activities with others in each project meeting and training session. Lab technicians and academic staff would support their training sessions and help them deepen their own understanding on the skills of handling those important lab instruments and share their knowledge in the designed video. In Fig. 2, volunteers are grouped in two and live discussions on the usage of designated instruments are encouraged. Live feedbacks will be provided by staff to clear out volunteers' doubts and confusions.

Fig. 2. Training sessions for student volunteers

As one of the main findings, it was observed during the project that student volunteers take active-learning approaches to prepare their videos. Several rounds of discussion were undertaken between team members on specific tasks. Feedbacks from staff were carefully considered and addressed and reflected in the final product of video. This type of project-based practice could be further applied to motivate students to participate in active learning and improve their academic performance accordingly.

Fig. 3. Video recording by volunteers

III. Video Tutorials

Based on the learning needs arising from our lab practices, we arranged 4 teams of year-two students on the following commonly-used lab instruments: oscilloscope, multimeter, signal generator and DC power supplier. These four instruments are widely adopted for different electronic labs. Student volunteers are suggested to use plain English and explain the concepts and terms in a language to be easily understood by their peers. As planned in advance, the project is designed to produce a series of video tutorials based on students' actual

learning needs. We will provide a number of analysis using the actual project video products as below.

In the video tutorial on oscilloscope, the volunteers demonstrate different useful information in experiments. One of the examples is the trigger control. A trigger is used to catch the displayed signal in the same location every time the signal is captured [12]. The purpose of trigger control is to obtain a static appearance for repetitive signals. Many options provided for trigger controls usually confuse students who have little experience of using oscilloscope. From the viewpoint of lab practice, most of signals for which the trigger control needs to be applied can be simply addressed by adjusting the triggering voltage level. In the video tutorial, volunteers provide this simple solution to stabilize the signal. A snapshot on trigger control is shown in Fig. 4.

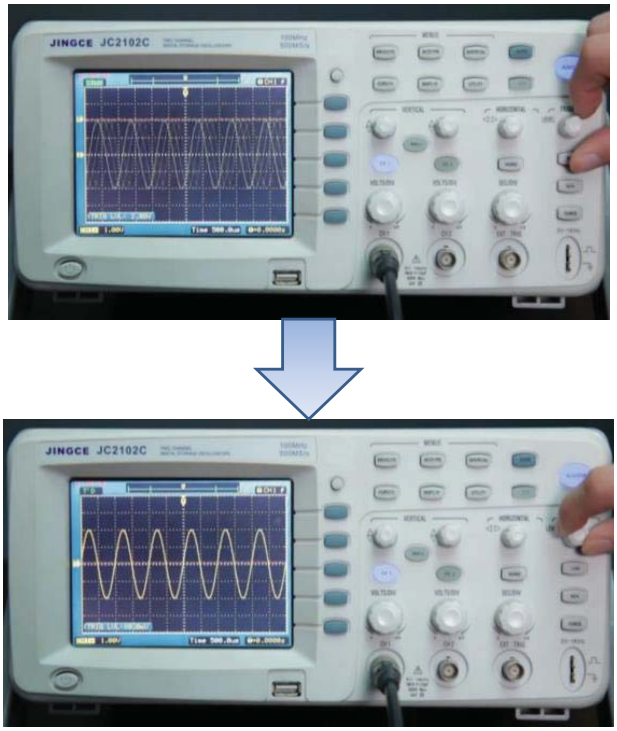
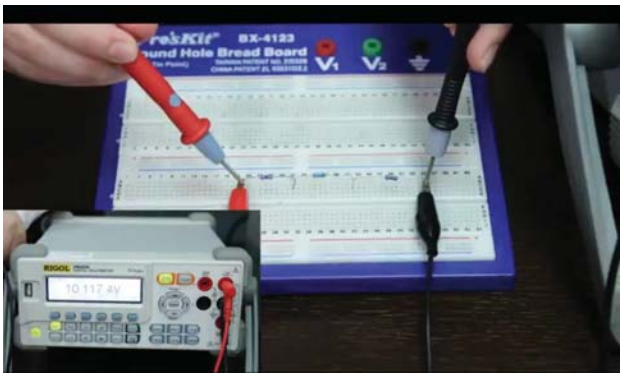


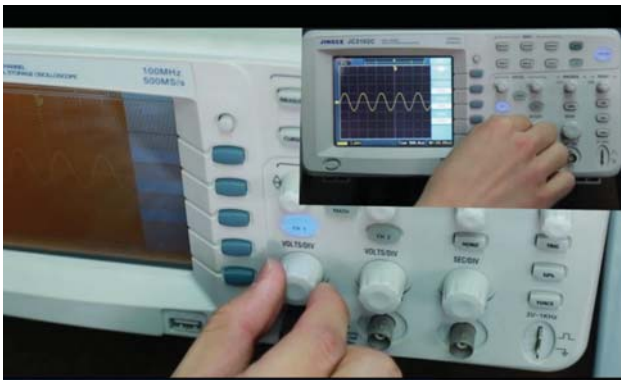
Fig. 4. Video tutorial on trigger control of oscilloscope

Digital Learning Resources Hub uses embedded videos where two information flows on both actions and the corresponding effect can be shown simultaneously. We provide the following two examples as shown in Fig. 5

Based on the above observations, the video tutorials are generated based on student's previous learning experiences. The prospective students will well benefit from these tutorials by avoiding similar mistakes and clarify the key concepts before the lab. Much time is supposed to be saved using these video tutorial to improve the efficiency and learning performance of students.



(a) Video tutorial for digital multimeter: the effect of different measurement can be demonstrated simultaneously



(b) Video tutorial for oscilloscope knob division: signal waveform change and finger motions are demonstrated simultaneously

Fig. 5. Embedded videos are used on special scenarios when two information flows need to be shown at the same time.

IV. Further exploitation of video together with online platform

In our current practice, lab-based teaching is equipped with online platform: ICE, the virtual learning environment at Xi'an Jiaotong-Liverpool University [11]. After generated and edited, these videos are posted on ICE and freely accessible for students as extra learning resources. As one of many powerful functions of ICE, the heatmap as shown in Fig. 6 enables instructors to see how students have actually watched the videos and how many times have these videos been watched. One can observe that each videos are clicked for multiple times, highlighting repeated use of these video resources.

A three-phase lab-based learning and teaching model was first introduced in our previous paper [11]. We now further develop this model for specific applications with these video tutorials. The details of model is shown in Fig. 7. In order to support students to better prepare for the lab, students need to take online quizzes before they enter the lab for experiments. The quiz questions are designed based on information delivered by videos and other supporting resources including lab manual and lecture notes etc. It is worth mentioning that students' performance can be closely monitored and analyzed for continuous development of the video contents and other resources [11].

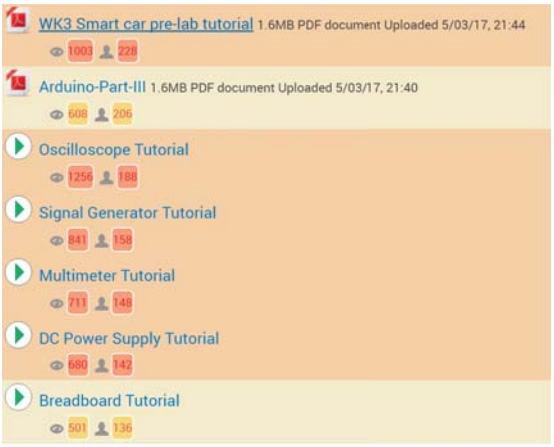


Fig. 6. Heatmap of uploaded videos on ICE.

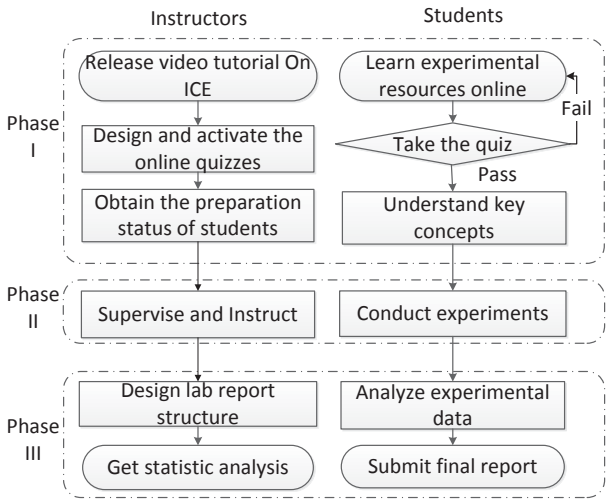


Fig. 7. A three-phase model: video tutorial incorporated with online platform.

A questionnaire based on the online platform ICE has been conducted with students who watched the videos and potentially benefited from the videos. The results reflect that 84% of the responding students strongly agree or agree that the videos help their experiment skills, 86% of responding students prefer watch videos rather than instructions in texts or pictures and 82% of responding students strongly agree or agree the videos are clear and easy to understand.

V. Future work

In this paper, we propose to apply student-generated videos to enhance student learning performances in laboratory. The generated videos boast plain English, customized contents, high video quality, familiar faces from peers and easy access via online platform. However, it is well understood that further study should be focused on analysis of the effectiveness of the proposed practices leading to students' success. In future work, we would like to introduce comprehensive comparative studies to collect evidences of effectiveness using well-supported assessment methods proposed by solid references. Under the ethical constraints, volunteers are to be recruited for the comparative study in which live introduction, popular videos from Internet and student generated videos are to be presented to different groups of students while their performances of these students will be evaluated using online quizzes and live assessment.

VI. Conclusions

In summary, we have demonstrated an on-going project on student-generated video tutorials to promote one-to-one additional tutorials to "flip the laboratory" in this paper. Feedbacks of the usage of these videos for a year-two undergraduate module have been found to be positive and student-centered idea in the project executions is highlighted via the full involvement of student volunteers. Further study needs to consider using comparative study to investigate the effectiveness of the videos and propose a standardized video generation procedure to ensure high video quality for different learning and teaching purposes.

Acknowledgment

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