# Learning Skills from Distance: A Solar Photovoltaic Site Survey from Students' View

Alias Masek, Muhammad Nurtanto, Nur Kholifah, Farid Mutohhari, and Rizal Zainal

***Abstract*—This study was to investigate the effectiveness of teaching skills using online medium for solar site survey, as well as students perceived on learning site survey using online medium. A survey study was conducted that involved 30 students who enrolled in a solar PV installation and maintenance course. An online questionnaire consists of eight items using five points Likert Scale were adapted from previous study, gauging students perceived on learning site survey using online medium (i.e. online lecture, WhatsApp, chat, voice, picture, short video clips, and learning management system-LMS). An assignment was used to indicate students' performance in site survey skills, including a short test to gauge students' technical skills knowledge, consisting of a total of 10 Multiple Choices Questions (MCQ), were developed by referring to the syllabus, under subtopic of solar site survey. Technical knowledge questions were divided into two types namely, items for testing concept (i.e. tools), principles (i.e. relationship of sunlight and shading) and procedures (i.e. application of knowledge). The result: Student average achievement in technical knowledge test was 68.3% (M = 6.83, SD=1.64); student average achievement mark in a solar site survey sketch is 62.8%; and students perceived on learning solar PV site survey was at high level (M = 3.99, SD = 0.69). It is concluded that solar PV site survey skills are possible to be implemented from distance through online medium, and it can be improved through a more video packaged in the form of live sessions.**

***Index Terms*—Teaching skills, learning management system, PV site, technical knowledge.**

## I. Introduction

A new challenge for Technical and Vocational Education and Training (TVET) practitioners in all fields, especially for teachers to train students that involve hands-on skills training through online medium, due to a pandemic of the COVID-19. The online learning is the only approach that is available during the movement restriction in force [1], worldwide. Without any reasons, theoretical, practical, or simulations (which is applicable) must be delivered from distance, utilizing the most recent medium and technology, including social media [2]-[4], Learning Management System (LMS) [5], [6], or web 2.0 [7], as long as students reach at the intended learning outcomes [8], and concern on students' third learning domain, namely "affective" [9], including perception [10].

The inclusion of teaching skills or skills training into online medium has been not well documented in the literature. Only a few resources available that reveals the approaches and strategies, using digital learning platforms but not necessarily from a distance. For instance, [11] the most effective strategy for teaching skills using online is involved conducting group exercises and role plays synchronously in the chat room, with a good interaction [11], [12], was, however, infusing soft skills instead of hard skills (i.e. Welding, wiring, sewing, cooking, etc.) for teaching Master Business Administration, including skills such as doing consultation, communication, problem-solving and thinking skills. Another most recent study [13], using virtual reality to teach hands-on skills involving engineering design and product development. The findings indicated that using virtual reality was more effective compared to the hands-on face-to-face approach [14]-[16]. However, when student stay at home, virtual reality equipment is beyond students afford to get one, especially within the unprecedented situation of COVID-19.

In online teaching, the facts that only a few selected procedures of practical laboratory from the list can be implemented from a distance, after considering several aspects including tools and equipment, as well as safety precautions. A few selected laboratory procedures might include the tasks for preparing technical analysis and calculation, designing the layout, and wiring drawing, and doing circuit simulation using a freeware software. Another task that might be possible to be taught using an online medium, is a site survey for solar Photovoltaic (PV) module tilting, around the student's vicinity place (residential area), with a very strict safety precaution step. The success of this particular laboratory procedure depends on the delivery approach of the instructor or teacher, to enable students to conduct site surveys from distance learning. Therefore, this study was to investigate the effectiveness of teaching skills using the online medium for solar site survey, as well as students perceived on learning site survey using online medium.

## II. Literature Review

Solar Photovoltaic (PV) installation and maintenance are one of the compulsory core courses under the Bachelor of

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Technology in Electrical System Maintenance with honour, in the faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia. This course is a five credit hours course, which requires two hours of lecture and three hours of practical session per week, along 14 weeks. The main goals for this course were to enable students to assess, install, and maintain solar PV system configuration for stand-alone and grid-connected according to standard requirements.

Solar PV Installation and Maintenance was first implemented for the first cohort students in the last February 2020 in their second semester of year 1. This course had been implemented with four weeks for face-to-face meeting before the campus was affected by the recent pandemic situation, thus online teaching and learning has been implemented in the rest of the remaining weeks. One of the most important topics within the course; is a solar site survey, requiring students to be able to conduct a solar PV site survey and prepare a sketch for the next process before designing and installing of a solar PV system, especially for residential use. The main purpose of this exercise is that students would be able to decide the most suitable place for tilting the solar PV module by considering the sun path and angle to minimize shading by the vicinity objects. Solar site survey topic was taught in the fourth weeks during the movement restriction in force, using the online medium. Meeting time for all lecture sessions were prefixed based on the existing timetable (as in the face-to-face meeting). For this topic, all learning materials were given out before the class session through LMS, provided by the institution, including a copy of the PowerPoint slide, a short video clip, solar site survey example sheet, and a solar site survey checklist. Students were first given a short lecture on the theoretical part using power-point slides. The lecture was conducted synchronously using WhatsApp, with audio voice recording for each slide. In addition, a short video clip demonstrating procedures for preparing a sketch for site survey was shared on WhatsApp and uploaded to the LMS, to give a general view of the most important elements to be included in the sketch. Students were encouraged to have a two-way interaction in WhatsApp, especially those who might need some time to digest the information delivered during lecture. Specific learning outcomes and comparison between normal and pandemic situation are presented in Table I. An individual assignment was given at the end of the class session and a short quiz to be completed before the class session ended. Students were then answering a technical knowledge test after class ended within a stipulated time frame. Students were given a week to submit the solar site survey sketch report consisting of the front-page consisting of student information, a complete checklist, and the site sketch using paper and pencil.

It is compulsory for technical students, the briefing on the general safety precautions during practical skills session was given in the first meeting. Then, before the session begun, students were given a specific briefing on the specific safety measures through lecture and a short video clip, for example students must be accompanied by someone during site survey.

TABLE I: LEARNING OUTCOMES AND COMPARISON OF DELIVERY APPROACHES

| Session | Learning outcomes | Normal situation (Face to face) | During pandemic (Online medium) |
|---|---|---|---|
| Lecture | to be able to grasp basic and procedural knowledge on solar site survey | Should be using PowerPoint slides and face-to-face lecture session. | using PowerPoint slides with audio on WhatsApp |
| A video clip | to be able to perform solar site survey procedures correctly | Should be face to face demonstration in the field | A short video clip demonstration and example of solar site survey sketch |
| Assignment | to be able to prepare a solar site survey sketch correctly | Should be completing a solar site survey and submitting report bya group | Completing a solar site survey and submitting an individual report |

## III. RESEARCH METHODS

### A. Research Design

A descriptive quantitative study was implemented. A survey study conducted using an online questionnaire to gauge students perceived on learning site survey using online medium, an open-ended question to collects students' suggestion for future improvement. To evaluate the effectiveness of teaching using the online medium, the student's assignment was analysed to indicate their performance in site survey skills, including a short test to gauge student's technical skills knowledge.

### B. Populations and Samples

A total of 30 students (20 male and 10 female) who enrolled in a solar PV installation and maintenance course (14 weeks-semester 2 2019/2020) have involved. Site survey was taught in the 6$^{th}$ week, during movement restriction is in force. Students were asked to submit an assignment online using the LMS (i.e.: Academic Online Resources-AUTHOR) platform within one week. The test was given in the following weeks, that was also conducted online using AUTHOR.

### C. Instruments

This study using three instruments, first: a multiple-choice question, second; a rubric scoring for solar site survey sketch, third; a perception questionnaire.

Firstly, a total of 10 MCQ was developed by the researcher, by referring to the syllabus, under sub-topic of solar site survey. The researcher is a teacher for this course with more than 10 years of experience in teaching, especially in engineering education and professional education. Technical knowledge questions were divided into two types, namely, five questions of basic technical knowledge [items for testing the concept (i.e. Tools) and principles (i.e. Relationship of sunlight and shading)] and five questions for procedural knowledge (i.e. Application of knowledge), [17]. Example of basic knowledge is "*what would be the most recent and useful tools needed for site survey?*" and procedural knowledge "*What would be the first to evaluate when reaching at the solar site location?*". Items were developed in native language (i.e.: Bahasa Melayu) since they were

first-year students. A correct answer is equivalent to one mark, and then the total correct answer was converted to a percentage. The MCQ test is included in Appendix A.

Secondly, A scoring rubric was used as a guideline for marking. The assignment given in this case evaluating students' skills in sketching the solar site survey, including eight areas as in Table II (scoring rubric). Marks were given based on the most important elements in the students' site sketch, based on accumulated weightage to a maximum of 15 marks. The overall marks then in converted to a percentage.

TABLE II: STUDENTS' SKILLS IN SKETCHING THE SOLAR PV SITE SURVEY

| Areas | Weightage |
|---|---|
| Direction indicator | 1 exist 0 not included (north direction) |
| Block drawing | Rating 1-5 (line drawing appropriateness) |
| Block dimension | 1 exist 0 not included (in feet of meter) |
| A clear obstruction | 1 exist 0 not included (obstructions e.g. trees, building) |
| M Box | 1 exist 0 not included |
| Solar angle | Rating 1-3 (indicate complete information) |
| A clear location | 1 exist 0 not included (safety e.g human, animal, risks, etc) |
| Bonus additional information | Maximum 2 (Solar PV size, cabling, etc) |
| Total mark | 15 |

An online questionnaire consists of eight items using five points Likert scale were adapted from the students perception on online learning [9], which is very close to this study context in gauging students perceived on learning site survey using the online medium (i.e. Online lecture, WhatsApp chat, voice, picture, short clips video, LMS). Students need to give their rating on each item based on their agreement on the statement given, for example, "*I get the picture of doing a site survey from a short video clip given by lecturer*" and "*I know to use the solar pathfinder from online lecturer's explanation*". Another additional open-ended question for students giving their suggestions for future improvement in the course. The reliability index was tested using Alpha Cronbach, the result was at 0.93 and deemed appropriate for research, [18].

### *D. Data Analysis*

Online questionnaire data were descriptively analysed using mean score and percent. Students' technical knowledge using MCQ was given marks according to students' score one mark for a correct answer. The student's site survey sketch (assignment) was given mark based on rubric. Both marks were used as students' skills' performance in site survey, as well as indicate teaching effectiveness.

## IV. FINDINGS

### *A. The Effectiveness of Teaching Skills Using Online Medium for Solar PV Site Survey*

Teaching effectiveness was evaluated based on students' achievement in the solar PV site survey according to students' achievement in technical knowledge test and the solar PV site survey sketch. Student's achievement in technical knowledge was tested using MCQ, the overall mean score (M) for students' achievement in the technical knowledge test is 6.83 (Standard deviation, SD = 1.64), which is equivalent to 68.3%. A comparison was made between knowledge of basic (Q1-Q5) and knowledge of procedural (Q6-Q10), results indicated that students scored higher in procedural knowledge (M= 3.90, SD=1.06) compared to basic knowledge (M=2.93; SD=0.94). The overall result is presented in Table III.

TABLE III: OVERALL STUDENT SCORE ON MCQ TEST OF SOLAR PV SITE SURVEY TECHNICAL KNOWLEDGE

| | Mean | Std. Deviation |
|---|---|---|
| Total_score | 6.83 | 1.642 |
| Total_score_Procedural | 3.90 | 1.061 |
| Total_score_Basic | 2.93 | .9444 |

A student's achievement mark (indicating technical knowledge) in a solar site survey sketch indicated the average score is 68.2%. It is consistent with the MCQ test score (indicating skills) level of achievement (68.3%), indicating that students' technical knowledge and skills are going equivalent or at a similar level when teaching and learning skills using the online medium for solar site survey. An insight into each pair of data, student 1 (S1) to student 30 (S30), indicates almost similar performance at both knowledge and skills tests. Table IV shows students' overall achievement in the MCQ test and solar site survey sketch, while the sample of students' solar site survey sketches is attached in Appendix B.

TABLE IV: STUDENTS ACHIEVEMENT SCORE ON SOLAR PV SITE SURVEY SKETCH

| Student | MCQ test score (%) | Solar PV site survey sketch score (%) |
|---|---|---|
| S1 | 60.0 | 60.0 |
| S2 | 70.0 | 53.3 |
| S3 | 90.0 | 60.0 |
| S4 | 60.0 | 73.3 |
| S5 | 80.0 | 86.7 |
| S6 | 50.0 | 73.3 |
| S7 | 80.0 | 73.3 |
| S8 | 80.0 | 60.0 |
| S9 | 80.0 | 73.3 |
| S10 | 70.0 | 60.0 |
| S11 | 80.0 | 80.0 |
| S12 | 80.0 | 73.3 |
| S13 | 50.0 | 53.3 |
| S14 | 50.0 | 86.7 |
| S15 | 80.0 | 60.0 |
| S16 | 80.0 | 53.3 |
| S17 | 80.0 | 93.3 |
| S18 | 70.0 | 73.3 |
| S19 | 40.0 | 80.0 |
| S20 | 40.0 | 73.3 |
| S21 | 80.0 | 73.3 |
| S22 | 90.0 | 86.7 |
| S23 | 80.0 | 80.0 |
| S24 | 80.0 | 53.3 |
| S25 | 70.0 | 60.0 |
| S26 | 80.0 | 46.7 |
| S27 | 40.0 | 53.3 |
| S28 | 70.0 | 80.0 |
| S29 | 30.0 | 33.3 |
| S30 | 60.0 | 80.0 |
| **Average score** | **68.3** | **68.2** |

### *B. Students Perceived on Learning Solar PV Site Survey Using Online Medium*

Based on the students' responses on the five-point Likert scale, a descriptive analysis was performed to find the mean score for each item. The result indicated that the overall mean is at a high level of students perceived on learning solar site survey skills using the online medium at M = 3.99 (SD=. 69). The highest mean score sounds like students can prepare a site survey sketch by refereeing to materials given during lecture (M=4.20, SD=.847). The lowest mean score sounds like students have a clear regarding the preparation of site survey requirements from online lecture (M=3.77, SD=.817). The rest of the items are presented in Table V.

TABLE V: STUDENTS' PERCEIVED LEARNING SOLAR PV SITE SURVEY FROM DISTANCE

| Question Item | N | Mean | Std. Deviation |
|---|---|---|---|
| 1) I am satisfied with learning how to conduct solar PV site survey using an online | 30 | 3.83 | 0.874 |
| 2) I am clear regarding the preparation of site survey requirements for an online lecture | 30 | 3.77 | 0.817 |
| 3) I can follow the procedure to conduct a site survey via online learning | 30 | 4.00 | 0.788 |
| 4) I get the picture how to conduct site surveys using video from the lecturer | 30 | 4.07 | 0.785 |
| 5) I am confident that I can use solar pathfinder based on online lecturer's explanation | 30 | 3.90 | 0.845 |
| 6) I can prepare a site survey sketch by referring to materials given by the lecturer | 30 | 4.20 | 0.847 |
| 7) I can calculate the shading percentage using pathfinder after attending an online class | 30 | 4.10 | 0.923 |
| 8) I can prepare a complete site survey sketch after attending an online class with the lecturer | 30 | 4.03 | 0.765 |
| **Overall mean** | | **3.99** | **0.831** |

### *C. Discussion*

Online medium is the only available platform during the COVID-19 pandemic striking. Besides teaching theoretical and conceptual, teaching skills is facing a very tough challenges to be implemented from a distance, considering the absence of physical tools and equipment; only a selected procedure can be taught using online medium. Enabling students' skills in conducting solar PV site survey was one of the possible procedures. The success of particular steps and procedures depends on multiple approaches and strategies during delivery. Therefore, this study was to investigate the effectiveness of teaching skills using online medium for solar site survey, as well as students perceived on learning site survey using online medium.

In this study, students' achievement on the technical knowledge of basic and procedural indicated that, achievement much better on procedural knowledge compared to basic knowledge. This finding can be justified that student's focus might had been distracted during online theoretical lecture for basic knowledge, since this was their first time to undergo the course with full online learning, which has been associated to multiple variables that might have influenced its effectiveness [19]. On the other hands, student's achievement in the practical work that they have done indicated encouraging findings. This is aligning with the experiential learning theory, where students should have gained and remembered more the procedures that they did and performed compared to the theoretical knowledge (basic knowledge) delivery during online lecture [20].

An in-depth analysis indicated that students as a whole are able to prepare the solar site survey sketch, whereby the module must be located in a clear obstruction and a clear location. This situation describes that student might have understood the most important rules of tilting solar module, might be either from the short lecture or video given. However, students seem to have difficulty determine the solar angle and preparing block drawing. The strongest reason is that the solar angle has involved some analytical and calculation skills, which is difficult for them to understand. While block diagram was successfully sketched but most of them without a proper line and dimension, which is subjected to multiple reasons. It is learnt that students need reinforcement on a particular area on the solar PV site survey sketch.

Students' perceptions expressed through surveys on the solar PV site survey using online medium; have resulted an encouraging finding. In this case, students possess a good perception about learning from distance. It can help them gather the skill to prepare a site survey sketch by referring to materials given by the lecturer (i.e.: video clips, solar site survey example sheet, and checklist). The materials shared by the lecturer was very informative, example given and clearly indicating the basic requirements of preparing the location survey sketch. It is learned that learning from a distance can make possible with complete materials, especially examples. According to previous research, example-based learning is a powerful learning method to teach students a particular skill [21]-[23]. At present, online medium-based learning is a solution in a pandemic situation. However, aspects of competency must be conveyed and measured. This requires a good strategy and consideration. Because not all competencies in the TVET field have the same characteristics. Some of TVET's learning must still be held by hand-on, of course; these conditions require clear and safe procedures. The availability of materials in the student environment and safety in learning is important to be considered by the lecture. The solar PV site is one of TVET's competencies that can be held through online medium. Therefore, there will be many differences of multiple variables to caters especially in term of affective aspect compared to normal learning environment. For example, discussion opportunities, finding the right source of literature, and others. The implementation of the solar PV site learning can be accepted by students, but learning strategies and materials need to be considered. TVET in other competencies must be delivered and measured.

Learning is stated to be good throughout the process, if the initial conditions until the end of learning are indicated by the students' performance increasing [24]. However, learning from distance has a big risk, especially on students' understanding. The lecturer must monitor every change in

activity and ensure that students are in the appropriate activity. As long as learning using online medium takes place remotely, some of them need "reminder messages" from implementing learning in addition to wanting direct "*discussion*" [S.5]. This has happened to a small proportion of students, expressing their unpreparedness with distance learning. The situation is normal due to changes in learning activities from face-to-face learning activities with on-line. However, they express fun during online activities: "*learning using voice notes is presented on each slide*" [S.11, and S.16], "*online learning using WhatsApp is simpler to solve internet problems and clarity of display in the form of images and clarity on sound*" [S.16]. However, every learning process has shortcomings that must be completed in the next process. They want the solar site construction to have a "*video demo*" and even a "*live session*" of the solar PV site, [S.7, S.14, S.18, and S.25]. Students' skills will improve if given a live demonstration, [25].

TVET learning in the COVID-19 era must still be carried out and carried out through distance. The role of TVET is considered to be able to provide life skills even students can obtain competencies that are aligned in the industry [26], [27]. At present, online medium-based learning is a solution in a pandemic situation. However, aspects of competency must be conveyed and measured. This requires a good strategy and consideration. Because not all competencies in the TVET field have the same characteristics. Some of TVET's learning must still be held by hand-on, of course; these conditions require clear and safe procedures. The availability of materials in the student environment and safety in learning is important to be considered by the lecture. The solar PV site is one of TVET's competencies that can be held through online medium. Therefore, there will be many differences of multiple variables to caters especially in term of affective aspect compared to normal learning environment. For example, discussion opportunities, finding the right source of literature, and others. The implementation of the solar PV site learning can be accepted by students, but learning strategies and materials need to be considered. TVET in other competencies must be delivered and measured.

## V. Conclusion

Teaching relevant skills using online medium for solar site survey topic is possible; the implication is that teaching skills using online must be done using multiple approaches and strategies of delivery. In this case, students are able perform a site survey and prepare solar site survey sketch after undergoing a short lecture (given with PowerPoint slide with synchronous online learning), given with a short video demonstration, and given a task (i.e. assignment), indicated by their performance in technical knowledge test, and performance in solar site survey sketch with all materials are given through LMS. In addition, students perceived that learning site survey using online medium indicated a positive and encouraging feedback. Therefore, in the time of pandemic, it can minimize a face-to-face contact hour to avoid spread of virus, but students still can learn technical knowledge and skills through online medium. Future direction of research should get in sight into students' engagement in learning skills and assessing students' learning effort, produces a significant impact to improve teaching delivery.

## Appendix A-Technical Knowledge

### *A. Basic Knowledge*

1) Why we need to have site survey?
   a. To have a good design of solar tilting
   b. To avoid wasting energy from the sunlight
   c. To avoid shading of the solar module in the long term
   d. To avoid lighting strike on solar module in the future
2) What would be the most recent and useful tools needed for site survey?
   a. Compass
   b. Handphone
   c. Camera
   d. Path finder
3) These items should be included in the solar site survey form except.
   a. Client details
   b. Electrical assessment
   c. Load profile
   d. Residential interior design
4) For domestic purpose, where should the solar module be appropriately titled?
   a. On the roof top
   b. On the ground
   c. On the wall
   d. On the yard
5) For domestic purpose, where should the solar module be appropriately titled?
   a. On the roof top
   b. On the ground
   c. On the wall
   d. On the yard

### *B. Knowledge of Procedures*

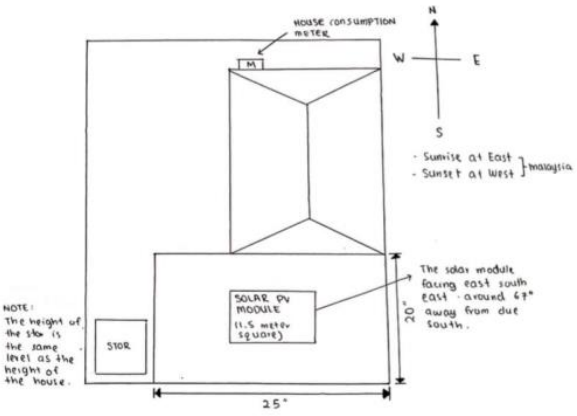
1) What would be the first to evaluate when reaching at the solar site location?
   a. Evaluating the roof
   b. Tracking the sun path
   c. Check obstructions
   d. Identify solar tilting possible place
2) Which of these should be the right order for choosing solar tilting for residential?
   a. Ground, roof, wall
   b. Wall, roof, ground
   c. Roof, wall, ground
   d. Roof, ground, wall
3) What is the "**don't**" step during finding solar angle using paper and pencil?
   a. Putting the pencil as an aimer
   b. Looks through the protractor
   c. Look directly to sunshine
   d. Check direction using compass
4) Using solar path finder, rank order the correct procedures?

- Sketch the shading reflection
- Mount onto tripod and setup balancing
- See the glass dome on top of the chart
- Calculate the shading

a. ii, iii, i, iv
b. i, ii, iii, iv
c. iii, i, ii, iv
d. iv,iii, ii, i

5) How should be the view of the sketch of the site survey?
   a. Front view
   b. Bird's eye view
   c. Ground view
   d. Light view

## APPENDIX B- SKETCHING SKILLS




## CONFLICT OF INTEREST

The authors have declared that no competing interests exist.

## AUTHOR CONTRIBUTIONS

A. Masek – Study framework development, instrument development; manuscript writing, and data analysis.

M. Nurtanto – visualization/presentation of data in text, manuscript writing, and manuscript submitting.

N. Kholifah – data input, and correction.

F. Mutohhari – typing, correction, and editing

R. Zainal – data collecting, correction, and editing

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