Evaluation Plan for the Solar Array Maintenance Training Program

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IDT 8130

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February 9, 2022

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Abstract

The Melink Solar Array Annual Maintenance Training Program was created to provide training and reference materials for staff electricians and apprentices to perform annual maintenance on the Cincinnati Zoo's solar arrays. Through the use of multimedia, this training program is designed to teach the target learners what they need to know about photovoltaic (PV) systems and the zoo's PV systems so they can integrate this with their prior electrical knowledge to conduct annual maintenance procedures. Think-aloud user observations and questionnaires will be used to evaluate (1) the material is at the appropriate level for the target audience, (2) the program adequately prepares the target learners for the performance context, and (3) the perceived usefulness and ease of use of the learning object. A questionnaire for the SME will evaluate the accuracy of the learning content.

Background

The Melink Solar Array Annual Maintenance online learning program, created with Adobe Premiere Pro and Captivate and delivered in Articulate Rise, is designed to teach staff electricians at the Cincinnati Zoo how to perform annual maintenance on the zoo's solar arrays. The zoo has several solar arrays, each one designed and installed by Melink Solar. While Melink is responsible for replacing or repairing system components, performing annual maintenance ensures that the systems are clean, sound, and free of shade to operate at their fullest potential.

The target learners for this program are licensed electricians and apprentices in the zoo's maintenance department. The purpose for creating a solar array maintenance training program is to document the maintenance procedures performed by a Melink technician, then provide this information to staff electricians so basic photovoltaic (PV) system maintenance can be performed in-house.

Members of the zoo's maintenance department are always on the move. Maintaining a 65-acre park means that staff rarely sit down, let alone at a computer. Their days are spent on foot or in electric carts responding to problems and projects all over the park. An online training program for them must be concise, relevant to the performance context, and easy to access from mobile devices.

The design of this learning object was guided by Mayer and Moreno's cognitive theory of multimedia learning (n.d.). This theory is based on the principle that humans have two channels by which they intake and process information, verbal and visual (Mayer & Moreno, n.d.). In multimedia learning, narration is processed by the verbal channel, and video (animation or live action) is processed by the visual channel (Mayer & Moreno, n.d.). There are three significant cognitive processes at work when students learn through multimedia. The first, selecting, happens when the learner intakes narration to form a text foundation and intakes video to form an image foundation (Mayer & Moreno, n.d.). The second, organizing, is when the learner takes these foundations to create verbally- and visually-based models of the learning subject (Mayer & Moreno, n.d.). The third, integrating, "occurs when the learner builds connections between corresponding events (or states or parts) in the verbally-based model and the visually-based model" (Mayer & Moreno, n.d., p. 2). These principles guided the design of the video segments, which I felt were the best format to address the training problem.

The training problem is two-fold. The first problem is that even with the ever-increasing use of solar power in this country, electricians still receive very little training on PV systems. The other problem is that the frequency of these maintenance procedures is too low for target learners to retain without a refresher. To solve these problems, the learning object needs to accomplish two tasks. The first task is to teach target learners what they need to know about PV systems while showing them how this information is relevant to the performance context. This is important for two reasons. By including a multimedia piece on PV systems prior to the maintenance demonstrations, I am using the pre-training

method for reducing cognitive load (Mayer & Moreno, 2003). This will help the target learners build both component and causal models, meaning they will understand how the PV system components work and "how a change in one part of the system causes a change in another part" (Mayer & Moreno, 2003, p. 47). By linking these components to those in the performance context, I am both encouraging the cognitive process of integrating (Mayer & Moreno, n.d.) and addressing relevance from Keller's ARCS model (Dick et al., 2015). The second task of the learning object is to offer instruction in segments, not only to reduce cognitive load (Mayer & Moreno, 2003), but also make it easy to access just the information they need for a refresher. Additionally, the learning object must be easy to update as the zoo upgrades and expands its PV systems.

My main resource for the content of this learning object is the Melink PV technician, Nathan, who demonstrated the maintenance procedures for each of the zoo's solar arrays. He was scheduled to be on site for just two days last summer, so I had to make the most of the opportunity. I filmed Nathan as he performed combiner box checks for each array. Creating training content from the footage was not a smooth and orderly task, however. Sometimes Nathan performed other tasks that are not part of annual maintenance. These segments were extraneous to the learning object and omitted. Sometimes Nathan encountered a faulty component and was forced to adjust the maintenance procedure to complete the task. My hope is that by providing pre-training with the multimedia segment on PV systems, I gave the target learners enough new information to integrate with their prior knowledge as electricians/apprentices to successfully navigate the maintenance procedures on their own.

In designing this instruction, I followed the first four of Gagne's nine events of instruction:

1. Gaining attention
2. Informing the learner of the objective
3. Stimulating recall of prior knowledge

4. Presenting the stimulus (Driscoll & Burner, 2022, p. 140).

To gain the target learners' attention and prepare them to receive instruction, I created an introduction segment using images and video footage that were both visually engaging and relevant to the performance context. I also inform the learners of the objective during this segment. In the segment on PV systems, I attempt to stimulate recall of their prior knowledge as electricians/apprentices by using familiar terms like *series* and *parallel connections* and showing footage of Nathan using a multimeter. I then present the stimulus, starting in the PV segment, by emphasizing the critical aspects of the learning objective, followed by demonstrations of maintenance procedures with corresponding verbal information (Driscoll & Burner, 2022).

The purpose of evaluating this program is to determine whether (1) the material is at the appropriate level for the target audience, (2) the program adequately prepares the target learners for the performance context, and (3) users are satisfied and perceive the learning object as useful and ease of use.

Evaluation Methodology

The small number of my target learners and ease of access to them will allow me the opportunity to employ a combination of think-aloud user studies (Schmidt et al., 2020) and contextual interviews (Usability.gov, 2022) in addition to usability questionnaires. These methods are perfectly suited for a small group of participants. In *Learner and User Experience Research*, Schmidt et al. (2020) quote Jakob Nielsen (1993) as saying, "thinking aloud may be the single most valuable usability engineering method" (Chapter 1, Section 4.7, paragraph 1). In a think-aloud user study, I will observe the users as they navigate the learning object while speaking their thoughts aloud. This kind of information is more qualitative than quantitative, and qualitative results are more likely to spawn ideas for improving the learning object (Interaction Design Foundation, 2021). Making these evaluations

contextual will be the observation of learners using their technology in the actual learning environment along with providing questions and scenarios (Usability.gov, 2022). Allowing participants to engage with the learning object on the device of their choice (desktop, tablet, or phone) using the internet connectivity provided in the performance context (the zoo's Wi-Fi) will yield qualitative results during in-person evaluations as well as generate quantitative results for the questionnaires participants will receive afterwards.

Two different questionnaires will be employed in this evaluation. One will be a user-centered questionnaire given to the target leaners after they use the learning object. It is designed to evaluate the perceived usefulness and ease of use of the learning object, as well as learner confidence and satisfaction. The other questionnaire will be designed specifically for the subject matter expert (SME) to record the location and details of inaccuracies in content as he views the learning object.

The think-aloud observations will be conducted one-on-one with the four target learners. After coordinating with their supervisor, I will send them a pre-evaluation email explaining the observation and confirming the time and location as well as their intended device. The observations will be recorded on video, with the focus on the screen of their device and the user's commentary. The user questionnaires will be distributed via email after the observations. The SME questionnaire will be emailed with instructions to Nathan at Melink.

Evaluation Instruments

The instruments for the evaluation of this learning object are the user observations, the user questionnaires, and the SME questionnaire. The users will be recorded while navigating the learning object on their device of choice, and the questionnaires will be emailed to participants as a Google Form link.

User Observations

Users will be observed in a quiet area to facilitate video and audio recording quality. As recommended by the Interaction Design Foundation (2021) in *How to Conduct User Observations*, users will be informed that the camera will primarily record their screen and their audible comments, and that the footage will be viewed only for the purpose of data analysis. Users will also be informed that they are helping to evaluate the learning object by thinking out loud as they navigate through it while they are observed for the ease with which they navigate the program, their reactions to the videos, and if the content prepared them for the reviews (Interaction Design Foundation, 2021). In addition to recording, the observer will guide the user with the following prompts:

- Users will be directed to progress through the course from start to finish, including the reviews. They are free to pause or rewatch videos.
- Upon completion, users will be asked to find and open the drawing for the Vine Street Canopy array.
- From that page, users will be asked to find where to watch just the segment on the Wild Dog array.
- Users will be asked if they wish to express any final thoughts before the observation concludes.

The format for this method of observation was inspired by author Steve Krug's video, *Rocket Surgery Made Easy by Steve Krug: Usability Demo,* in which Krug demonstrates a usability test for a website using the think-aloud user study along with provided questions and scenarios (2010). His data recording method is a screencast with audio of the user interfacing with the website which documents her interaction with the GUI, her thoughts spoken aloud, and the Krug's questions and scenarios.

User Questionnaire

The user questionnaire is based on Lund's USE questionnaire and is intended to evaluate the usefulness, satisfaction, and ease of use of the learning object (Perlman, 2021). The questionnaire will be emailed to users as a Google Forms link after they have completed the observation. A sample of the questionnaire can be found in the Appendix.

SME Questionnaire

The SME questionnaire, also in Google Forms, is designed to make it easy for the SME to document inaccuracies as they work their way through the course. The form will be divided into sections corresponding to the video segments in the learning object. Each section will have open-ended questions in which the SME can note the timestamp, the inaccuracy, and the correction for that video segment. This questionnaire can be also found in the Appendix.

Sampling Methodology

The participants will be the target learners, which include both certified electricians and apprentices, another member of the maintenance department, the SME (Melink PV technician), and myself as the researcher. The Interaction Design Foundation (2021) recommends that when preparing for user observations, it is important to select a sample group that is representative of the target users. The Melink Solar Array Maintenance online learning program was created for electricians and apprentices in the zoo's maintenance department. This currently consists of just four people, but the program is also intended for future hires. Fortunately, despite the small sample size of target learners, the group has an equal number of certified electricians and apprentices, which will help evaluate the effectiveness of the program for future hires of varying levels of electrical experience. However, since all of the target learners were present for Nathan's demonstrations last summer, I included a member of the maintenance department who has no knowledge of the solar arrays in hopes that this will offer

further perspective of a new hire. The SME is Nathan, the Melink PV technician who performed the maintenance procedures shown in the learning object.

Analysis Procedures

The evaluation will generate both quantitative results from the questionnaires and qualitative results from the observations. The quantitative results from the questionnaires will be exported to a spreadsheet from Google Forms for analysis. To analyze the qualitative results from the observations and the open-ended questions on the questionnaire, I will follow the five steps as recommended by CampusLabs (2020):

1. Prepare and organize your data.
2. Review and explore the data.
3. Create initial codes.
4. Review those codes and revise or combine into themes
5. Present themes in a cohesive manner. (para. 1)

To prepare and organize the data, I will watch each recorded session, transcribe all comments and observations, and organize them by the corresponding segment of the learning object. I will read over and examine the data for consistencies and further ways to organize it. I will highlight words and phrases to code key information, then review the codes to identify recurring themes. Finally, I will present these themes in a manner consistent with the goals of the evaluation.

Conclusion

The Melink Solar Array Annual Maintenance Training Program was designed to teach staff electricians and apprentices how to perform annual maintenance on the zoo's solar arrays. The program content consists primarily of multimedia segments. The design of these segments is based on Mayer and

Moreno's cognitive theory of multimedia learning with the intent that they help target learners build a mental model of PV system components and how they work (n.d.). By using familiar terms and images, the multimedia segments aim to stimulate the learners' prior electrical knowledge so that they may integrate this with the new knowledge of PV systems. Using photos and footage taken in the performance context gives relevance to the content. The goal of these design strategies is to give learners the new knowledge they need about PV systems to combine with their prior knowledge as electricians and show them how they will apply this knowledge on the job. This evaluation plan will determine where the design strategy is successful and where it needs improvement regarding whether 1) the material is at the appropriate level for the target audience, (2) the program adequately prepares the target learners for the performance context, and (3) users are satisfied and perceive the learning object to be useful and easy to use. A small but diverse group of participants accurately represents the target learners. Think-aloud observations and the open-ended questions on the user questionnaires will generate ideas for improvement. User questionnaires will generate quantitative results, and the SME questionnaire will evaluate content accuracy. Collected data will be analyzed and used to generate improvements to the learning object.

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Appendix

User Questionnaire

	User Questionnaire for the Melink Solar Array Annual Maintenance Training Program								
	Adapted from Gary Perlman's USE Questionnaire (2021)								
	USEFULNESS		1	2	3	4	5		NA
1	The program helps me be more effective	strongly disagree						strongly agree	
2	The program helps me be more productive	strongly disagree						strongly agree	
3	It is useful.	strongly disagree						strongly agree	
4	It makes the things I want to accomplish easier to get done.	strongly disagree						strongly agree	
5	It meets my needs.	strongly disagree						strongly agree	
6	It does everything I would expect it to do.	strongly disagree						strongly agree	
	EASE OF USE		1	2	3	4	5		NA
7	The program is easy to use.	strongly disagree						strongly agree	
8	The program is simple to use.	strongly disagree						strongly agree	
9	It is user friendly.	strongly disagree						strongly agree	
10	It requires the fewest steps possible to accomplish what I want to do with it.	strongly disagree						strongly agree	
11	It is flexible.	strongly disagree						strongly agree	
12	Using it is effortless.	strongly disagree						strongly agree	
13	I can use it without written instructions.	strongly disagree						strongly agree	
14	I don't notice any inconsistencies as I use it.	strongly disagree						strongly agree	
15	I can recover from mistakes quickly and easily.	strongly disagree						strongly agree	
16	I can use it successfully every time.	strongly disagree						strongly agree	
	EASE OF LEARNING		1	2	3	4	5		NA
17	I learned to use the program quickly.	strongly disagree						strongly agree	
18	I easily remember how to use the program.	strongly disagree						strongly agree	
19	It is easy to learn to use it.	strongly disagree						strongly agree	
20	I quickly became skillful with it.	strongly disagree						strongly agree	
	SATISFACTION		1	2	3	4	5		NA
21	I am satisfied with the program.	strongly disagree						strongly agree	
22	I am confident the program prepared me for the job.	strongly disagree						strongly agree	
23	I would recommend it to a friend.	strongly disagree						strongly agree	
24	It is fun to use.	strongly disagree						strongly agree	
25	It works the way I want it to work.	strongly disagree						strongly agree	
26	I feel I need to have it.	strongly disagree						strongly agree	
27	It is pleasant to use.	strongly disagree						strongly agree	
	List the most **negative** aspect(s):								
1									
2									
3									
	List the most **positive** aspects(s):								
1									
2									
3									

SME Questionnaire

Content Accuracy Evaluation Form - Melink Solar Array Maintenance Training Program

Please review the program content for accuracy.
Note the location of the **inaccuracy** in each **segment** with the **timestamp** [00:00] and the **correction.**

Segment	Timestamp	Inaccuracy	Correction
Introduction	0:00		
PV Systems	0:00		
Wild Dog	0:00		
Hippo	0:00		
Canopy	0:00		