

## ICT-TOOLS SUPPORT TOYOTA WAY PRINCIPLE 6

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This paper pursues to discuss how the implementation of Information and Communication Technologies (ICT)-tools could support standardized work ( The Toyota Way, principle 6). This will be done through a theoretical discussion. Furthermore, a case study will show a practical example, -a web application as an ICT-tool solution to support standardized tasks-. The web application is intended to help the standardization of assembly instructions, help learn novice and experienced operators, and increase the knowledge sharing. The case study has no documented instructions, and as a consequence, there is a high risk that all this knowledge can be lost in the future.

Keywords: ICT-tools, Lean, Standardized work, Toyota Way, Web application.

### 1. INTRODUCTION

This paper aims to discuss how the implementation of Information and Communication Technologies (ICT)-tools could support standardized work ( The Toyota Way, principle 6). This will be done through a theoretical discussion. Afterwards, a case study will show a practical example in the form of a web application as an ICT-tool solution to support standardized tasks. The web application is intended to help the standardization of assembly instructions, help learn novice and experienced operators, and increase knowledge sharing. The case study has no documented instructions. As a consequence, there is a high risk that all this knowledge can be lost in the future.

Companies invest millions of dollars in ICT to improve organizational or individual performance (Goodhue, 1995) and still continue, particularly in e-business applications, such as Enterprise Resource Planning ERP (Falk, 2005), (Riezebos, Klingenberg, & Hicks, 2009). For this reason, we need to make sure we are developing and implementing ICT-tools that really fulfill the operators needs and support them in their tasks. Due to the fact that operators will use for the first time a web application as an aid for task standardization, it is important to evaluate its acceptance and usage in order to provide a useful and durable solution. To carry out this, a combination of 4 Usability methods: Technology Acceptance Model TAM (Fred, 1989), Task Technology Fit Model TTF, Thjahjono's survey items (Tjahjono, 2009), and IBM Computer usability satisfaction (Lewis, 1995) were used.

The best manufacturing practice is not about the application of the latest machine and technology only; it also must include the manufacturing system and management (Jaffar, Hayati, Halim, Yusoff, & Mara, 2012). For instance, Toyota success resides on tools like pull systems, error proofing and standardized work; but also count with a deeper business philosophy based on its understanding of people and human motivation. Moreover, its success is ultimately based on its ability to cultivate leadership, teams, and work culture, to devise strategy, to develop suppliers, and to maintain a learning organization. 14 principles comprise "The Toyota Way". These 14 principles are also the foundation of Toyota Production System (TPS). TPS is the basis for much of the "lean production" movement that has dominated manufacturing trends for the last decades (J. Liker, 2004). The power behind TPS is a company's management commitment to continuously invest in its people and promote a culture of continuous improvement (J. Liker, 2004). One of the 14 Toyota Way principles pertain to task

standardization, principle 6. Standardized work helps mitigate bottlenecks, overprocessing and overproduction in an assembly line. It is not possible to think on improvements when there is no standardization. Tasks and processes standardization is the pillar for continuous improvement and employee empowerment (J. Liker, 2004).

## 2. INTRODUCING ICT AND PRINCIPLE 6-STANDARDIZED WORK

The increased demand for multi-skilled and autonomous operators, coupled with the requirement to adhere to the work standard, has put more pressure on provision of continual training and skill development (Tjahjono, 2009). It is central to provide effective tools to support operators in their tasks. Information and Communication Technologies (ICT) can deliver the correct information at the right time, and at the right place. The use of ICT in Lean production has become more frequent (Riezebos et al., 2009), (Powell & Strandhagen, 2007). More related to standardized tasks, is Tjahjono's work published in (2009), where he proposed an information system task-oriented to support shopfloor workers in a Telecommunication industry case study.

### 2.1. Web applications as an ICT-tool solution

Web applications provide ubiquity as it can reach different devices, from a desktop computer, laptops to smartphones and tablets, and more important, we can reach more users. The use of mobile devices-web applications as ICT-tools to help operators in their daily tasks, v. gr., by giving the correct information at the right time may reduce such type of wastes defined by Lean, like unnecessary motion, defects, printed information, etc.

### 2.2. Toyota Way Principle 6. Standardized tasks are the foundation for continuous improvement and employee empowerment.

It is hard to improve any process until it is standardized. If the process is shifting from here to there, then any improvement will just be one variation that is occasionally used and mostly ignored. One must standardize and thus stabilize the process before continuous improvement can be made. In fact, at Toyota the standard work is posted outward, away from the operator. The operator is trained using standardized work, then must do the job and not look up at the standard worksheet (J. Liker, 2004).

The Toyota Way shows that to remain competitive year after year and continually stay among the industry leaders, a company must have viable and enabling standards so it can continually improve upon repeatable processes. Use the standards and improve on them. Capturing knowledge is not the issue. The hard part is getting people to use the standards in a database and contribute to improving it (J. Liker, 2004).


### 2.3. ICT-tools and Standardized work matrix.


In order to categorize and evaluate the progress on using ICT-tools and task standardization, a matrix has been developed, see Figure 1. It is divided into novice and expert mode in the areas of implementing ICT-tools and Standardized work.


		Standardized work	
		Novice	Expert
ICT-Tools	Novice		
	Expert		


Fig. 1. The ICT-Standardized Work matrix.

The following sections will describe each quadrant in more detail.

 *Novice (ICT) – Novice (Standardized work)*. In this quadrant, the company has no strategies in either implementation of new ICT solutions or for task standardization. Operators use their tacit knowledge when performing a task (In working life we find many epitomes of tacit knowledge such as intuition, rule-of-thumb, gut feeling and personal skills (Haldin-Herrgard, 2000)). Training new operators is often done by an expert showing ‘the right way’ i.e learning-by-doing (Thompson, 2010). There is often no or little information used describing the work tasks.

 *Novice (ICT) – Expert (Standardized work)*. At this stage, the company has implemented standardized work and the knowledge has gone from tacit to explicit knowledge, meaning that this knowledge has become information, which has been collected and structured. Explicit knowledge is possible to store in a mechanical or technological way, like in handbooks or information systems (Haldin-Herrgard, 2000). Besides, the company is still novice in the ICT area, the information content is usually stored in binders far away from the users, which result in less using by the operators according to the cost-benefit theory (Jonides, 1984).

 *Expert (ICT) – Novice (Standardized work)*. The company is expert in ICT. However, there is a high risk that the company acquires new technologies without having a clear strategy on how to implement these technologies into the working environment due to its lack of experience in standardized work. This could turn into irritation among operators and decreased trust in automation (Parasuraman et al., 2008). As a result, we can get over-automated systems without a clear structure how to use the technology. It is fundamental to provide the correct ICT-tools to the operators and have a clear strategy.

 *Expert (ICT) – Expert (Standardized work)*. Both the knowledge of new technologies and the knowledge of standardized work are explicit and structured. The company uses different information carriers to support the operators and different media and content in order to optimize the information-sharing.

#### 4. CASE STUDY

The pursued goal of the case study was to validate how a web application as an ICT-tool solution could support work standardization (The Toyota Way, principle 6). To carry out this validation, the assembly time was measured in a way to quantify the improvement in the users’ learning in 3 different scenarios that will be explained in section 4.5. In addition, a usability test was performed to verify the acceptance of the web application as a supportive tool for the assembly task.

##### 4.1 Background- Current state

A process performed in a company in the metal cut industry includes an assembly stage. However, there are no instructions given to the operators but a CAD drawing of the product(s) to be assembled. There is a strong oral tradition and teamwork within the company. Some of the operators have been working for more than 20 years. The way novice operators learn, is by asking the experienced ones. All the knowledge has not been collected in any way, so there is a risk that all this knowledge can be lost in the future.

Two products were chosen to begin the standardization process. One that is frequently done, and easy to assemble; product A. The other one is hard to assemble; product B. Both products have different variants but the assembly parts used are similar and the tools to assemble are the same.

Figure 2 shows an overview of the case study, and the strategy of going from Novice in both ICT and Standardized work towards expert at both.

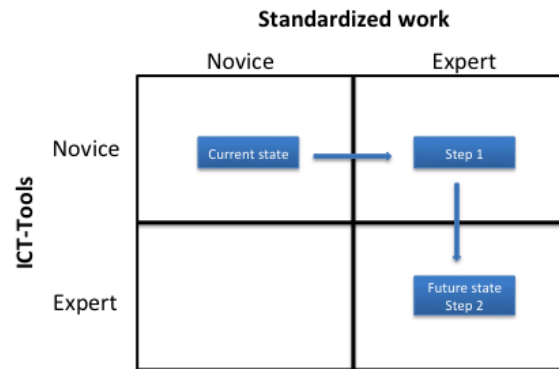


Fig. 2. Going from Novice-Novice towards Expert-Expert.

#### 4.2. Step 1: From Novice towards Expert using standardized work; From tacit knowledge to explicit knowledge

As a first step in the standardization process, assembly instruction knowledge should be collected, and should come from the workers (J. Liker, 2004). To carry this out, an expert operator was filmed while assembling the products. In addition, pictures were taken of every step of the assembly procedure. The expert operator was asked for what he thought it was the hardest part in the assembly procedure, and to provide tips to novice operators. The assembly instructions were divided into different steps. In each step one component is assembled.

#### 4.3. Step 2: From Novice Towards Expert using ICT-tools; a Web application prototype

Prototyping offers a quick way to incorporate user feedback into a design. A simple form of HTML offers a quick way of producing first scenarios (Holzinger, 2004). For this reason, HTML5 (latest release) was used to develop a web application prototype. This prototype consisted of assembly instructions of two types of products (A and B). Learning is an individualized process; therefore, learning aid resources such as, videos, and pictures were used. Taking into account different levels of expertise among operators, there were two types of assembly instructions: one for experts and one for novices. For experts, there was less information, while for the novices there was more detail and explanation. The purpose is that the expert just may need a reminder. Both types of instructions are accessible to novice as well as experts, see Figure 3.

In this stage of the prototype development, the efforts were focused on the content of the instructions. Basic features were added to the prototype, like links to facilitate navigation through the different steps, hide/unhide information to avoid saturation of information.



Fig. 3. Web-application layouts used in the case study.

#### 4.4. Evaluating the prototype: usability test.

Customers want usable products, and developers strive to produce them. It follows that an important part of modern product engineering, both hardware and software, must measure usability (Lewis, 1995). Usability is most often defined as the ease of use and acceptability of a system for a particular class of users carrying out

specific tasks in a specific environment (Holzinger, 2005). Usability can be measured with both objective and subjective variables. Objective usability measures include, but are not limited to: scenario, completion time, successful scenario completion rate, and time spent recovering from errors (Lewis, 1995; Whiteside, Bennett, & Holtzblatt, 1988). Subjective usability measures are usually responses to Likert-type questionnaire items that assess user attitude concerning attributes such as system ease-of-use and interface likeability (Lewis, 1995).

A 20-item survey (see section 4.6) was elaborated based on 4 different models: Task Acceptance Model, TAM (Fred, 1989); Task Technology Fit, TTF (Goodhue, 1998); Strömberg-Karlsson Acceptance scale forthcoming; IBM Computer Usability satisfaction questionnaire (Lewis, 1995); and Thjahjono's survey used in his work (2009), see Figure 4. The reason for combining 4 different models is that no model is 100% reliable. TAM has been fully criticized. Adding more models increased robustness of the survey. The items were 7-level Likert scale. 1 (the lowest level) means to strongly agree with the statement, and 7 (the highest level) means to strongly disagree. The models used are explained briefly in the next subsections.

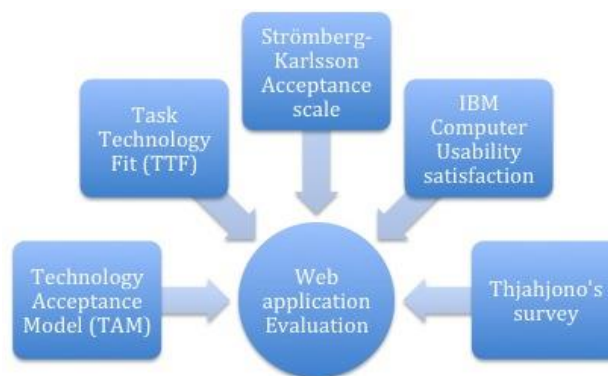


Fig. 4. Usability evaluating methods and sources.

*Technology Acceptance Model TAM.* Past research suggests there are two determinants that are particularly important. First, people tend to use or not use an application to the extent they believe it will help them to perform their job better; this first variable is referred as perceived usefulness. Second, even if potential users believe that a given application is useful, they may, at the same time believe that the systems are too hard to use and that the performance benefits are out-weighed by the effort of using the application; perceived ease of use (Fred, 1989).

*Task Technology Fit model TTF.* The heart of TTF model is the assumption that information systems give value by being instrumental in some task or collection of tasks, and that users will reflect this in their evaluation of the systems. Thus, the strongest link between information systems and performance impacts will be due to the correspondence between task needs and system functionality (TTF) (Goodhue, 1998).

*IBM Computer Usability Satisfaction Questionnaires.* Although user satisfaction with system usability is only one component of the multifaceted construct of usability, it is a very important component in many situations. The Post-Study System Usability Questionnaire (PSSUQ) was used. PSSUQ is currently a 19-item instrument for assessing user satisfaction with system usability, and allows participants to provide an overall evaluation of the system they used (Lewis, 1995).

The idea of applying usability test was based on Thjahjono's work in (2009), and some questions were taken from his study.

#### 4.5. Testing procedure at the company.

13 users tried the web application prototype; 11 company employees: 4 experts and 7 novices, and 2 bachelor level students who were doing their thesis at the company (can be considered as novice). The test started by assembling product A (easy one), and then the product B (hard one). The assembly time was measured as a way to quantify the improvement in learning by using the application. Three scenarios were tested with the users for product A:

1. Using instructions for novices.
2. Using the instructions for experts; and finally

### 3. No instructions.

Another dynamic was used for product B (hard one). It was implied that the user had gained some knowledge after working with product A and it was expected it would be easier for the user to assemble product B. The users were asked to assemble the product without instructions. In the end they required instructions, since it was not so intuitive to place the parts in the correct order. It confirmed the need of instructions.

During the practical evaluation, there was an expert operator to support the novice on how-to-use a tool, the hardest part of the assembly, and as quality control, to verify that the assembled product was assembled correctly. After the practical evaluation, the user was asked to answer the usability survey elaborated (see section 4.5). The questionnaire was published as an on-line form via Google Drive. For more information regarding the questions, visit the following link:

[https://docs.google.com/forms/d/1L4ahmpLNQQf9C4iv6Urwg11-h\\_tE43NjF8CBd0zeOdU/viewform](https://docs.google.com/forms/d/1L4ahmpLNQQf9C4iv6Urwg11-h_tE43NjF8CBd0zeOdU/viewform)

Moreover, a novice user was shadowed for 3 days. The novice user was asked to assemble product A once a day. The assembly time was measured to quantify the improvement. During the first day, the novice user followed the procedure mentioned above: to assemble product in the 3 different scenarios. The rest of the days he assembled without any instructions.

#### 4.7. Web application as a learning support; towards expert level in novice operators.

Table 1 shows the assembly times obtained for the novice users for product A; the minimum, mean and maximum times are given. It can be seen that the assembly times decrease considerably from instructions for Novice to instructions for Experts. This is due to the fact that novice users spend more time seeing the video instructions and the pictures since it was the first time they assembled the product.

Table 1. Assembly time: 3 scenarios – Novices (Product A).

Assembly time in [min:sec]	Scenarios		
	Instructions-Novice	Instructions-Expert	No instructions
Min	03:32	00:37	00:35
Mean	05:36	01:15	00:55
Max	08:02	02:06	01:14

Table 2 represents the assembly times for the expert users. Like in the novice users case, minimum, mean and maximum times are given too. We asked the experts to use the novice instructions as well, so they can provide feedback in order to improve the instructions. One of the experts was chosen to be the one that can be used as a reference when standardizing the cycle time in the future, see Table 3.

Table 2. Assembly time: 3 scenarios – Experts (Product A).

Assembly time in [min:sec]	Scenarios		
	Novice Instructions	Expert Instructions	No instructions
Min	02:21	00:43	00:40
Mean	02:52	00:57	00:45
Max	03:15	01:25	00:55

Table 3. Assembly time: Expert (Product A).

Assembly time in [min:sec]	No instructions
Min	00:23
Mean	00:25
Max	00:28

#### 4.6 Survey results.

In general, the users found the web application helpful for learning and complete the task (assembling the product). The users commented that they prefer bigger and more explicit pictures, closer shots while filming the operator, and time pace of the video.

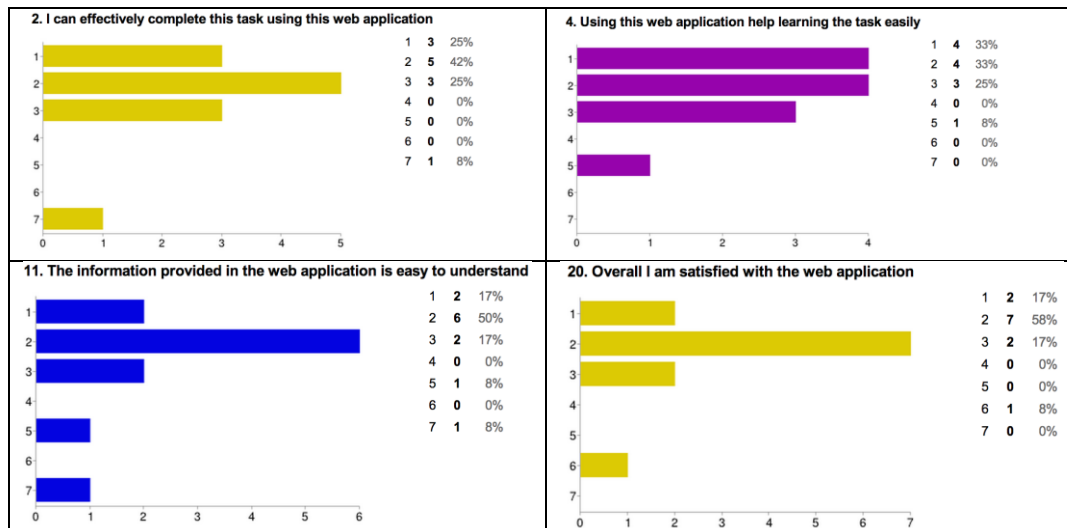


Fig. 5. 4 items results.

Figure 5 shows 4 of the 20 items of questionnaire results. The full results can be seen in the following link:

[https://docs.google.com/forms/d/1L4ahmpLNQQf9C4iv6Urwg1l-h\\_tE43NjF8CBd0zeQdU/viewanalytics](https://docs.google.com/forms/d/1L4ahmpLNQQf9C4iv6Urwg1l-h_tE43NjF8CBd0zeQdU/viewanalytics)

#### 4. CONCLUSIONS AND FUTURE WORK

The use of a web application as an ICT-tool solution to support work standardization (The Toyota Way, principle 6) seems promising. Most users were positive in trying the web application prototype. They found it helpful to assemble the product(s). The experts did not think they needed the instructions though. The application just consists of 2 type of products now. When the standardization process expands, the number of work instructions will increase, so it is important to always keep in mind to deliver an easy-to-use application.

The work standardization was delimited to the assembly instructions only. However it is recommended to analyse the whole assembly process to identify critical knowledge (J. K. Liker & Meier, 2007) to identify what to standardize and where there could be flexibility. In this stage of the case study, the main change was going from tacit to explicit knowledge in the standardization process. The highest effort was concentrated in collecting the correct information and show it in the most useful way.

Since the company is novice in terms of Work standardization, there could be a risk of over standardization and the instructions may become rigid. For example, the assembly steps are sequential because each assembly part precedes the other ones most of the times. However in some cases, there can be interchangeability between sequences. Also, there is no tool standardization. The operators just choose among a set of tools the one that fits the size of the screw. If it is not critical to the whole procedure, there could be some flexibility. One possible solution could be to show several assembly options to the novices so they can choose what it is easier for them to learn, when thinking about assembly steps.

Both products, A and B have different variants. What differs among them is the shape of the assembly part, if they are left or right, and the size. Further studies are recommended to see if such issues should be part of the task standardization and the assembly instructions. Additionally, investigate about the possibility to have generic assembly instructions. The observations during the tests showed that it could be doable. Instructions were done for 2 specific variants. When the tests were performed, a different variant of product A was used. Novice operators did not notice the difference between the instructions and the product to be assembled. Just one of the expert operators detected the difference.

Throughout the tests, it was possible to verify that the hardest steps in the assembly procedure for the novice were the ones that the expert mentioned when he was filmed. For those steps, tips were included. However, there were parts where it was impossible to collect all the knowledge because it was the type of knowledge gained by doing.

Keeping on learning new skills, tasks, and finding better ways of making operators tasks more efficiently are continuous improvement. Providing the correct tools to develop new skills to the operators is crucial in their way to become a better operator.

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