A SYSTEM FOR EVALUATING THE ONGOING BUILDING PROCESS – THEORY AND PRACTICE

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ABSTRACT

One of the reasons for the limited development in the Danish building industry is the lack of both documentation of achievements and the sharing of experiences. For solving this problem, a knowledge management and learning system has been developed with the aim of improving the learning as well as the communication and documentation of knowledge, both between the different trades in one project and between projects.

The system consists of two parts. The first part mainly aims to support learning and the verbal communication of knowledge from person to person. It is a learning circle called "Method of seven steps". The second part is a system for the administration of data used to evaluate the building process continuously – together the two parts form the system called SAVE – an acronym (in Danish) for "System for Administrating Data to Support Continuous Assessment and Evaluation of Projects".

The system is based on the measurements and commitment as known from the Last Planner System i.e. PPC and weekly planning meetings on the building site. In contrast to other systems, SAVE is a continuous assessment system that fits the actual challenges of the building project. The data and information, complemented by the personal competences of the workforce, result in a basis for action to be taken during the building process so that the people involved immediately will see the effects of the system.

From spring this year, the system will be tested on two construction projects, and experience gained from the tests will illustrate the viability of the system and the theories it is built on.

KEY WORDS

Communication, implementation, performance measurements, learning process, knowledge capture, lean construction.

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LEARNING AND KNOWLEDGE CULTURE IN CONSTRUCTION INDUSTRY

It has been argued that there is great potential in improving the building process (Taskforce 2000) and to exploit this many initiatives have been started in the Danish building sector (Bertelsen et al.). The different parties in these initiatives have often felt there is great potential in the ideas, but it has been difficult to improve or even copy the results on subsequent projects (SBI-rapport 316 1999; Anlægstekniskforening 2003). This could be due to the fact, that it is difficult to produce clear evidence of performance effects (Brensen 2001). This means it is hard for the participants of the initiatives to convince others in the sector to follow up on the improved building process.

According to Kasvi (2002) every project has several potential outputs:

- A product (or service) delivered for an internal or external costumer.
- Project knowledge concerning the product, its production and use:
    - Technical knowledge concerning the product, its parts and technologies.
    - Procedural knowledge concerning producing and using the product and acting in a project.
    - Organisational knowledge concerning communication and collaboration.

Unfortunately, all outcomes but the Product are mostly ignored on building projects. The knowledge generated about the building process and organisation knowledge has seldom been documented (Alsted 2003). When the members of a team from a building project disperse, the knowledge accumulated at the project disperses with them. Considering the fact that the individuals are likely to split up after the project, they do not see a reason for making any effort to share the knowledge and document the experiences. Furthermore, it has not been clear to the participants what it meant to be a part of a learning process (Clausen 2002), which again leads to an undocumented building process.

A further problem is that knowledge from previously projects is not being sought before a new project is started or during the course of a building project (Taks Force 2000). The pull and push problem is illustrated in Figure 1.

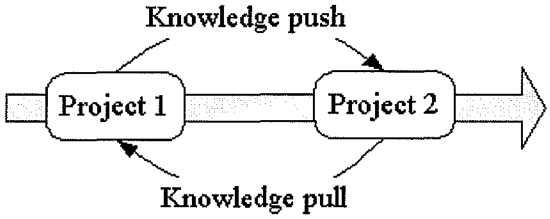

Figure 1: Push and pull of knowledge between projects, Ebbesen & Thomsen (2003).

Because of the lack of a push or/and pull of the knowledge mechanism between projects it is difficult to make continuous improvement between building projects, illustrated by the arrow.

In this paper, it is argued that even though there are many problems on the way to a better building process, there are still some improvements that could be done under given circumstances. One of these is to have a common learning process including both the push and pull of knowledge on the building project where all the different trades contribute their knowledge about the process.

LEARNING AND KNOWLEDGE TRANSFER IN PROJECT ENVIROMENTS

There are many reasons for the inconsistency of knowledge transfer between projects. Schindler (2003) describes the problem as project amnesia, which is caused by:

- High time pressure towards the project's end (completion pressure, new tasks already wait for the dissolving team).
- Insufficient willingness for learning from mistakes of the people involved.
- Missing communication of the experiences by the involved people due to "wrong modesty" (with positive experiences) or the fear of negative sanctions (in case of mistakes).
- Lacking knowledge of debriefing methods. Underestimation of process complexity which a systematic derivation of experiences brings along.
- Lacking enforcement of the procedures in the project manuals.
- Missing integration of experience recording into project processes.
- Team members do not see a (personal) use of coding experience and assume to address knowledge carriers directly as more efficient.
- Difficulties in co-ordinating debriefings. Persons cannot be engaged for a systematic project conclusion, since they are already involved in new projects.

The knowledge documentation and communications is further complicated by the knowledge about the process mostly being tacit knowledge which is knowledge stored in the mind of the participants on the building project (Lin 2003), (Koskinen 2003), (Bresnen et al. 2001). The knowledge gathered at projects is mostly tacit knowledge bound to the people who are personally involved in the project (Schindler, 2003). Knowledge is not an abstract but is embodied in the individual, in other words, every thing known is known by somebody, so rather than turning to databases an individual seeks knowledge from trusted and capable colleagues (Koskinen 2003). All these factors: time pressure; lack of motivation for documenting the experience; missing skills and discipline and finally the type of knowledge to be disseminated makes a common learning experience difficult in project environments in general.

The learning process on a building project is also influenced by the nature of the building industry. The characteristics of the building industry are said to be; Temporary organisations; Site Production and the one-of-a-kind production, (Koskela 2000). Therefore, the learning process at the project is influenced by the transient cooperation between various trades. A team is put together for a single project where after the team members disperse along with the knowledge accumulated through the project.

Because of the temporality and the fragmented sector every participant in the building project, especially between different trades, has their own way of speaking and listening, which can lead to misunderstandings (Brensen, 2003), (Koskinen, 2003). This means that the outcome of a learning process through a discussion between various trades will be different for each person. Each will leave the discussion with his or her own opinion about what was said and concluded. It is also likely that at the end of the project the participants will keep in mind the latest problems and forget the good things that happened during the project.

Because of not having a common learning process and not having communicated the learning experiences among the trades, a sub optimisation between the trades is very likely to occur. Each participant will leave the project with a one-sided view of how the project went. The participant will hereafter try to influence the subsequent projects according to this person's experiences from the previous projects.

The building companies could save considerable costs, which result from redundant work and the repetition of mistakes, if they master the project learning cycle (Schindler 2003). Nevertheless, methods for learning at projects often rely on making a status on the project (Schindler, 2003) more than pointing out learning outcome and issues for further investigation and learning experiences. If there is any evaluation of the project, this often takes place after the project has ended, and possible by consultants (Schindler, 2003) because the project participants has moved on to other projects.

This paper presents a learning cycle and a tool for supporting the learning process at the ongoing project. The basis for the learning cycle is Lean Construction and especially the Last Planner System (Ballard 2000) and the Benchmarking System developed by The Benchmark Centre for the Danish Construction Sector (Byggeriets Evaluerings Center 2002). First, an introduction to the factors that supports the learning process at projects is given where after the cycle and the toll is presented. The terminology used in the following will come from a building site production to simplify the descriptions. Nevertheless, the ideas are meant to be used at all phases in a building process

A COMMON LEARNING PROCESS

In this section a definition of *a common learning process* will be introduced. A common learning process results in a multi-faceted understanding for every project participant in the process and how their actions affect the building process (Ebbesen & Thomsen 2003). This understanding could be gained through discussions and communication about the building process. It does not mean that everyone must end up with the same opinion, but a greater understanding of the influences which one's actions or delays have on the work flow could prevent sub optimisation.

The learning process often consists of three elements:

- The different competences of the workers on the project
- Their experience from previous projects
- Experience from the current project.

The competences include for example the personals characteristics such as the stress tolerances (Koskinen, 2003). The experiences from previous and the current project include both explicit and tacit knowledge. Therefore, all three elements differ from person to person. If these three elements are the only topics of a discussion between the participants, each will leave the project with his own picture of the project. To have a common area of learning a neutral baseline for discussion must be established.

Data and information about the building process can be used to make such a neutral baseline for learning. Data and information about the process will often be considered more objective than statements from the other parties. With data and information to illustrate the work flow the discussion among the participants can start on common ground. In this way the discussions do not have to start revolving around problems which the different parties see from their own point of view. Instead the discussion starts with problems everyone can agree exist.

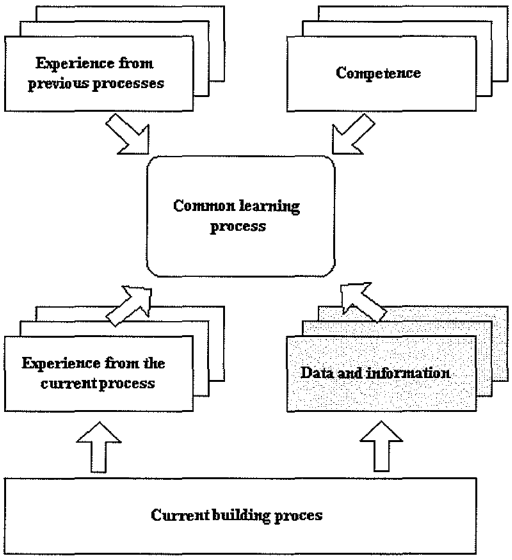

Figure 2: Illustration of elements in the common learning process, Ebbesen & Thomsen (2003).

The figure above illustrates the elements, which contribute to a common learning process. The two boxes at the top illustrate "Competence" and "Experience from previous projects", and these elements are individual for each person.

The two boxes "Experience from the current process" and "Data and information" are factors from the ongoing process. "Experience from the current process" is also an individual factor in contrast to "Data and information" which is an objective element in the common learning process.

THE METHOD OF SEVEN STEPS

From trainee experiences, the idea to a cyclic learning process emerged. The Method of Seven Steps was stepwise refined through presentation of the model and discussions with project managers, implementation consultants for Lean Construction, process managers at and consultants from The Benchmark Centre for the Danish Construction Sector. The model was also presented at a network meeting for process- and project managers working with Lean Construction. In this way, the model was developed to fit the actual needs for learning and benchmarking system at Lean Construction building sites. In this section, a plan of action to support a common learning process is presented.

The requirements for the process are: There must be established an objective ground for discussion; the participants should be able to see short term advantages and sub optimisation must be prevented.

The following shows the steps in the learning process, the Method of Seven Steps, which should be established on the project.

1. Continuous assessment of the building process.
2. Gathering knowledge from other previous projects (pull of knowledge).
3. Evaluating the process at the end of the project.

In these three steps, all participating parties at the time should contribute to the relevant extent. The learning process also consists of four further steps that should be carried out within the different parties. In order to obtain the most value from the system these four steps should support dissemination and utilisation of the knowledge achieved through the project.

4. Evaluating the single building process within the company.
5. Evaluating the building processes which the company has participated in by comparison.
6. Evaluating and reformulating the project-related strategies in the company.
7. Deciding on which areas to explore and bring out further investigations on the coming building projects (push of knowledge).

This paper focuses on the activities at the building project and will, therefore, be concentrating on the first three steps. These three steps will be further explained in the following sections.

Continuous assessment of the building process

In order to build the foundations for common learning, data and information must be considered as objective and relevant by all participants in the project. A way of ensuring this is to involve the participants in collecting and recording data from their own area of expertise. As with the Last Planner System (LPS) the craftsmen should be involved in collecting data on the process and in discussing problems that could arise during the project. As a result of involving all parties in collecting the data, the parties are committed to the process and the data can be considered as objective. In this way they know where the data comes from and what they are representing.

The impact on the workflow should furthermore be represented visually so that everybody can see and understand the problems and the improvements. The illustrations will show where the real problems are thus forming the starting point for discussion. This way objective data and information presented in diagrammatic form can be a common base for learning.

The assessment meetings should be held on a regular basis in order to achieve short term output improvements and to keep up the motivation (Schindler, 2003). By discussing the process on a regular basis, action can be taken to handle problems or to exploit emerging opportunities.

The data should be used in regular discussions about the building process and the work flow on the project with participation of all active parties. This could be the architect, consultant engineer, technical support and the main contractor in the design phase. In the construction phase it would more likely be the different sub contractors and the main contractor. By discussing the building process all trades can explain to the others what causes negative or positive effect on their workflow, and this way all trades obtain a greater overview of the building process. Knowledge depends off the point of observation (von Krogh 1996), therefore, it is crucial that the participants get the opportunity to explain their point of view on the situation. To this face-to-face communication is a very rich medium, because it allows immediately feedback and the understanding can be checked and interpretations corrected (Koskinen 2003).

Everyone can then contribute their own experiences and knowledge and discuss the causes of the problems. Furthermore, it is possible to utilise knowledge from previous experiences if the participants can easily recognise the problems, (See Figure 1). The weekly meetings also make a base for informal knowledge diffusion among the participants. This allows the participants to solve small problems and coordinate details in their work schedules, and thus avoid small issues to grow bigger.

Gathering knowledge from previous projects

Every project is unique, but there are, to some extent, general characteristics, which could be used to categorise the problems, the solutions and experiences. Thereby, the experiences can be used on later projects when similar problems arise. As problems arise in a project the participants should seek knowledge about the problem before trying a new solution, which, perhaps, has been previously tried out with poor results. It should also be possible to seek knowledge about a certain type of project before it commences This knowledge could be sought from previous projects both within the specific company and from the different parties involved in the project.

Of course stored data can not solve all problems in a project. As shown in figure 2, the data only forms a foundation for learning and databases only complement the personal networks of those seeking answers to problems (Koskinen 2003). Useful experience and knowledge about the process is primarily stored in the minds of people, which means that one of the most important things is finding people who have the necessary knowledge about the problem or the improvements developed during a project. These people could then act as consultants for the building process.

Evaluating the process at the end of the project

Often there is no final evaluation of the whole work process and if there is one it is likely to be an economic evaluation from a single company's point of view. To avoid sub optimisation a common evaluation of the project should be made as the project ends in order to obtain a common picture of the whole project period. Elements that went well and elements that could be optimised at later projects should be highlighted. This is perhaps the most important step in avoiding sub optimisation, so that the parties involved see the building project as a whole and not only from their own point of view.

With the same argument as at the first step, it is recommended that the evaluation start at a common baseline. This baseline could very well be the data and information from the process supplemented by the main points of the weekly discussions. If every person has become familiar with the data during the process, they will be inclined to accept the data as objective during the final evaluation. This also means that the evaluation can include the whole process and not just the last few months or weeks.

EXISTING SYSTEMS TO SUPPORT LEARNING

To some extent systems that could provide the basis for a learning system, as described above, have been developed but the focus has never been on supporting a learning process throughout the project period. Two particular systems in Denmark could be relevant to examine at this point: The Last Planner System (Ballard 2000) and the Benchmarking System developed by The Benchmark Centre for the Danish Construction Sector (Byggeriets Evaluerings Center 2002).

The purpose of the Last Planner System (LPS) is to make planning more accurate during the project. It focuses on improving assignments to direct workers through continuous learning and corrective action, and to proactively cause work to flow across production units in the best achievable sequence and rate, (Ballard 2000). The Weekly Work Plan and the measurements of Percent Planned Completed (PPC) have provided a great deal of inspiration to this Paper. By involving the workers in collecting data from the work process and discussing the problems a forum for informal discussion and knowledge sharing between the trades has been created.

The weakness of PPC, according to the objective of this paper, is that PPC only measures the completed tasks during the past week compared to the number of planned tasks. This does not show the impact which the delays have had on the building process. The learning experience will therefore be based on what seems to be the problems instead of what really causes problems in the work flow: *"...supposing one team first measures it's PPC at 60 % and another at 30 %. That doesn't mean very much. What matters is how rapidly each team learns to do better planning, the measure of which is the change in PPC."* (Ballard & Howell 2003)

Compared to the structure of the learning system as described above, LPS involves representatives from the different parties continuously throughout the project. The system also gathers data and information about the process through the PPC measurements and uses discussions in the learning process. However, because of the limitations within the available data, the PPC (see the quotation above), the problems that occur are not prioritised in response to the impact on the work process. This could result in unimportant problems being discussed at the expense of more important problems. Neither does the PPC support a common evaluation of the process, because the data is only relevant at the time measured.

Another system is the Benchmarking System[2] developed by The Benchmark Centre for the Danish Construction Sector[3]. The Benchmarking System collects both data from the projects and from the companies registered. The purpose of the system is to learn and communicate about best practice. The Benchmarking System makes it possible to compare two or more projects or companies using several parameters. This will in the future be used to identify best practice and the potential for further investigations.

The Benchmarking System challenges the building Industry at management level, and it encourages managers to disseminate the information from the system. It will take some time from the reporting of the data until conclusions can be made on a building project. In other words the system is focused on long term advantages and in organisational learning which does not match the requirements of a learning system with a focus on the specific project.

Together these systems comply with the requirements of a system to support a learning process, but they both have their weaknesses. Furthermore, the systems have significant influence on project management in the Danish Building Industry at the present time. Therefore, the two concepts should be included in a new learning system to keep the work load at a minimum on the projects.

SAVE – A SYSTEM FOR SUPPORTING COMMON LEARNING AT BUILDING PROJECTS

SAVE[4] was developed by two students as a part of their Master Thesis in Building Management, at Department of Production, Aalborg University[5]. SAVE is a system for supporting learning in a project – it is not a replacement for the Last Planner System nor the Benchmarking System but a supplement to the two systems. The main objective of SAVE is to support a learning process in building projects with data and information about the work process with respect to the nature of the building industry. The system contains three types of data (see Figure 3). A brief description of each type of data is presented bellow.

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[2] The Benchmarking System is among other projects inspired by "Rethinking Construction"

3 The Benchmark Centre for the Danish Construction Sector (Byggeriets Evaluerings Center) is a business foundation, established by a wide range of the players within the construction sector in order to promote the quality and the efficiency within the sector. (www.byggeevaluering.dk)

4 SAVE is an acronym for "system for administrating data to support continuous assessment and evaluation at projects" (in Danish).

5 Randi Muff Ebbesen and Kim Staunstrup Thomsen. Each of the students has through the final year achieved practical experience from a consultant and a contractor company respectively. They also attended several courses in Lean Construction, and had an instructor who worked with implementing Lean Construction on an everyday basis. Furthermore, some of the project results have been presented at The Benchmark Centre for the Danish Construction Sector and at several contractor companies and the responses have been included in the final report. Now Kim S. Thomsen is working within a contractor company and Randi M. Ebbesen is a PhD- student. The Master Thesis can be viewed at www.byginord.dk (in Danish)

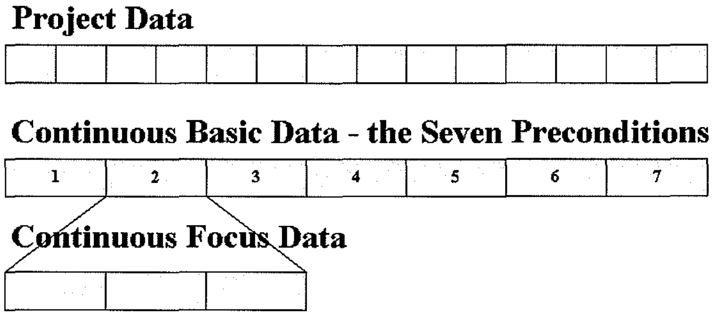

Figure 3: The structure of SAVE

Project Data

The Project Data is used to describe the building project. Project Data categorise the project and thereby make data and information from one project available for project managers on subsequent projects. By using the Project Data the project manager can seek information and data from previous projects. The information and data could contain description of relevant experience from problems encountered or innovations employed which could be useful on a current project. The manager could also track down people with knowledge about a certain problem or particular types of projects and use these people as consultants.

Examples of Project data: Renovation project, 2-storey, the company name of the client and all the trades involved, contract value etc.

Continuous Basic data

The Continuous Basic Data (CBD) is the main element in SAVE. CBD is used to measure the impact of different factors on the work flow.

Like in the Last Planner System the foremen gather at weekly meetings to plan the activities for the following week. This plan consists of an estimate of the number of working-hours necessary to complete the task and an estimate of time of the completion time for the task. If the task is not planned to be completed in the following week, the foreman should estimate the percentage of the task that is completed at the end of the week.

At the following meeting, the foremen register which tasks they did complete, as planned, in the past week. If there have been any delays the foremen should estimate by how many working hours the task was delayed and the reason for the delay.

$$CBD = \frac{\text{Hours delayed}}{\text{Hours planned for the task}}$$

The Continuous Basic Data is the delayed working hours divided by the planned working hours. This number can be calculated both for a specific trade and for the whole project that week.

This way the delay is shown in relation to the planned work that week. Furthermore, the reasons for the greatest impact on the flow can be spotted and addressed. e.g. a CBD for missing information about the design can be measured for the carpenter or for the whole project the past week.

There are seven preconditions for performing a task, (Koskela 2000): (a) construction design; (b) components and materials; (c) workers; (d) equipment; (f) space; (g) connecting work; and (h) external conditions.

The causes for almost all delays can be categorised as a shortfall in one or more preconditions. Thus, the basic measurement should only consist of categorising the delays according to the preconditions.

The CBD-measurements should be presented as diagrams showing the impact on the workflow from one of the seven preconditions. Visual representation of the results provides an overview and makes it possible for everyone to see deterioration and improvements in the building process.

Continuous Focus Data

The Continuous Basic Data is always held up against the seven preconditions. But if, week after week, it shows that the main reason for delays is missing information about the construction design, the CBD for "Construction Design" should be spilt up into, for example, 3 Focus Data: Information from the consultant engineer; information from the main contractor and information from the client. These more detailed measurements could then help identify the real reason for a problem, or for monitoring the effect of an improvement in, for example, the information flow.

This more specific data should only be applied in the period used for exploring the causes of a problem. When the cause is identified, this data should not be recorded any further in order to keep the workload to a minimum.

SAVE AND THE EXISTING SYSTEMS

There are many similarities between SAVE and LPS. The difference is that the measurement of PPC in LPS is meant to hold the various trades to their mutual agreements made in the weekly meeting. SAVE both requires the trades to keep their agreements and to demonstrate the impact of a broken agreement or shortfall in one of the seven preconditions has on the workflow at the project.

SAVE focuses on learning. By involving all parties in measuring the impact on the flow; by visual representation of the impact and by discussing the causes for delays the participants get a more detailed and holistic view of the building process. Everyone see the same problems through the measurements and they see the effects of the action taken to rectify the problems.

SAVE is built on the same assumptions as Last Planner of Production Control System, and the actions taken to measure the CBD are almost the same as PPC. In that way SAVE could be considered a module to Last Planner of Production Control System which focuses on learning.

There are also some similarities between the Benchmarking System and SAVE. Both systems have a focus on communication and learning, but the time frame is different. Despite that, the two systems can have a common interface which can secure data from SAVE being reported to the Benchmarking System.

APPLICATION OF SAVE

During their Master Degree Project two students[6] are testing SAVE at two different building projects. Their project is not yet completed, but the results to date from one of the projects will be presented in this section.

The building project testing on is a new building of a plant for DKr 680 mill. SAVE is tested at one sub contract at DKr 44 mill. which include all foundation and concrete. The team consists of a project manager, a chartered surveyor, two work managers, two foremen and approximately 50 workers.

The decision to implement SAVE at the project was made by the project manager and the aim was to ensure a more accurate planning process. Before implementation of SAVE the Master plan, which was made by the Head of Planning, was not revised according to delays in the working process.

The system was implemented in steps. First the foremen and work managers were introduced to the principles of planning the work for the following week and recording the reasons for delays according to the seven preconditions. In the next step, they also estimated the use of working hours and the delay in hours. Through the period of implementing and testing the system students took part of the weekly planning meetings. Furthermore, they spent time talking to the foremen and workers to help them plan their work for the following week.

This method of implementation meant that the foremen got used to the principles and that they always had a broad overview of the system. It also meant that the students who introduced the system could adjust the system to the conditions at the site. The stepped implementation also had the consequence that there was no visual outcome from the planning and the collection of data in the first phase. This affected the motivation, but as soon as the diagrams were made they served as a basis for discussion.

The main barriers for implementation were that the people involved were not used to planning the work in detail for the forthcoming week. They were used to moving the workforce from task to task according to the work pressure and bottlenecks. This meant that it was difficult to estimate how many work hours they would use for one task or how many hours a task would be delayed.

After using SAVE for a few months, it showed that the main reasons for delays for one of the crews were the weather and shortage of workmen because of illness. After confronting the project manager with the data it was decided to hire two more workers on to the crew. The project manager would probably have discovered the need for the workers anyway, but with the system the need became visible much earlier and action was taken before the delays had crucial impact on the workflow.

The system started a friendly competition between the two crews, but it also meant that the foremen sometimes "forgot" to record tasks in the week's plan so that they could gain a higher score. However, after explaining that SAVE was not for evaluating the performance and capacity of foremen and workers, but only a tool for improving the common learning process and the planning, this problem vanished.

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[6] Simon Sundahl Mortensen and Thomas Nørgaard Christensen, Master Students at Department of Production, Aalborg University.

EVALUATION OF THE APPLICATION OF SAVE

The provisional testing of SAVE shows great importance of getting reliable data from the system. If the data is not reliable it will not give an accurate picture of the working process, and this means the discussion will be initiated by imaginary problems. Therefore, it is very important to pay attention to the reliability of the data. It should on the other hand be remembered that the main objective of SAVE is to support a learning process and not to collect accurate data for a research project. In other words, some flexibility around the data should be allowed as long as, for example, the delays are estimated after the same procedure each week.

Regarding securing the reliability of the data, several potential difficulties have been highlighted. Firstly, it has shown that it is important that the workers and foremen at the building project are familiar with the concepts of Last Planner System. If the participants are not used to these procedures or in planning the work for the following week in detail they cannot get reliable data from the system. The experience from the application of SAVE here by stated that application of SAVE require Last Planner to be implemented at the project.

It is also crucial that the managers are 100% committed to the implementation and use of the system. In some cases the managers have not been given the necessary support to implement either SAVE or Lean Construction. These managers do not see the potential in the systems and are unlikely to call on the workers to participate in collecting data.

A challenge for implementing SAVE is to handle the fact that SAVE will give the participants more paper work than usual. This can sometimes lead to frustration among, for example, the craftsmen who would prefer to be out on the building site. However, if the workers see the purpose of the data collection and the subsequent discussions they will make an effort to record reliable data.

DISCUSSION

It is too early to conclude if SAVE can actually initiate a learning process at building projects. However, indications show that some kind of learning process is initiated. For example, at the building project mentioned above a reason for many delays was that the foremen often underestimated the tasks because they did not pay enough attention to the instructions. As a consequence they started examining the instructions more carefully before estimating the time needed for each task.

For the time being the primary complication regarding the implementation of SAVE has been to make the crews and managers comprehend the system and to secure reliable data. By first implement the Last Planner System, these complications would have been diminished. From the experiences with the application, it is recommended to understand SAVE as an addition to Last Planner System that focuses on ongoing learning based on performance measurements. The results of the system will not be fully visible until the system is a natural part of the planning process.

If SAVE is used on more than one project, the effect of push and pull of knowledge will start to be visible. All participants own the data of one project and it is up to the involved companies to ensure that the knowledge is carried forward to next project. Again, it should be kept in mind that the data is only a support for the learning process. The actual learning and creation of knowledge takes place in the minds of the participants. If someone remembers something about a certain aspect of a building project the data should guide him to find more information about the experiences from previous projects. Perhaps he can find a person within his own company who has dealt with a similar problem, or he can be inspired by documented solutions.

However, in order to gain useful knowledge from earlier projects the data must be reliable and the users of the data must have the competence to think in abstractions because no building projects are the same.

It was also argued that SAVE could be used in order to secure knowledge about successful improvements. The part of SAVE, that is focused on collecting data, is mostly concentrating on finding potential improvements and not on defining success, so SAVE alone will not be able to push knowledge about successful improvements from one project to another. However, if the elements in the development initiative are properly documented the results could be evaluated through SAVE. By viewing the outcomes of SAVE in context with the documentation from the project the development initiative can be evaluated. The weekly discussions about the workflow and the building process can also be used to raise the participants' consciousness regarding the effect of the initiative.

There remains, however, the challenge of finding a systematic way to secure knowledge between projects for continuous improvement of the building process. This will be the objective of my PhD-thesis.

CONCLUSION

SAVE was developed to support an ongoing learning process in respect of the nature of the building industry. This learning process should be initiated by involving the participants in the project in collection of data from the building process by investigating what causes delays and discussing the results of the data processing.

The system is being implemented at two building projects, and so far the results from both projects show some barriers but also a great deal of potential. A precondition for using SAVE is that LPS is implemented. However, the use of LPS is not always fully understood and the principles are still new for many managers. In these cases, SAVE would only lead to frustrations because it is not possible to collect reliable data.

Despite the challenges in implementing SAVE, the system also shows great potential. By using SAVE attention is paid to the problems that have the most impact in the work flow and action can be taken earlier than usual this being a more proactive approach.

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