Value stream mapping in education: addressing work stress

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Abstract

Purpose – Teachers of primary education experience high levels of stress but lack rational coping strategies to reduce their work stress. The paper develops a value stream mapping for education approach and examines its use as a rational coping strategy for teams of teachers and other employees to overcome work-related stressors.
Design/methodology/approach – The research process consists of two phases. First, a value stream mapping approach for education is developed, based on literature research. Next, the approach is validated in an action research study to reduce work stress of teachers in educational services. The processes that have been selected by the teachers relate to coping with increased variety, long and uncertain throughput times and unclear specifications.
Findings – Value stream mapping for education (VSM4EDU) is a well-structured improvement method based on principles of visualization, participation and process thinking, which helps teachers without background in lean thinking to analyse their processes. Using this method has enabled the team to develop rational coping strategies to reduce their work-related stress.
Research limitations/implications – VSM4EDU has been validated using action research at a single school, which implicates deep insight, but further testing at other schools is welcome. Moreover, VSM4EDU has not been used to develop a future state map.
Practical implications – Value stream mapping is useful in educational settings as long as the educational context is respected in the approach.
Social implications – VSM4EDU empowers teachers and helps to develop co-operation in teams.
Originality/value – The validation of value stream mapping for education is well-documented and original.

Keywords Educational lean, Continuous improvement, Work stress, Team development

Paper type Research paper

1. Introduction

Work stress of teachers and other employees in education is a persevering problem as there are many contributing factors. In American primary education, a study of Stauffer and Mason (2013) showed that a major impact on work stress among teachers was caused if schools used prescribed standardized tests not only for monitoring progress of pupils but also for comparing the performance of individual teachers. In a European study, Antoniou *et al.* (2013) found that teachers of primary education experience higher levels of stress compared to teachers of secondary education. Uncertainty or conflicts on their roles and tasks is a very important contributor to work stress as well as the work load, time pressure, lack of autonomy and motivation, lack of a cooperative team culture, lack of public recognition and appreciation and not enough involvement in decisions on tasks.

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A major factor that might explain the perceived work stress of teachers is the availability of rational coping mechanisms. Antoniou *et al.* (2013) distinguish emotional coping mechanisms and problem-focussed coping mechanisms. The former is directed towards external recognition of the problem and its consequences, while the set of problem-focused coping mechanisms aims at addressing and solving the problem. We denote them as rational coping behaviours, which help teachers overcome work-related stressors and burnout and achieve their valued outcomes with their pupils. Based on the observation that teachers often work in isolation without adequate support for personalized work methods from the organizational level due to limited resources, the expectation is that teachers do not have full access to problem-focussed coping mechanisms and hence are not capable of addressing and solving the work stress problems themselves.

Industry workers faced similar problems. However, empowering people at the shop floor has resulted in the development of very practical tools and methods that provide support to these people in identifying and resolving emergent issues in their daily work. One of these tools is value stream mapping (Rother and Shook, 1999). It is a visualization method that helps a team first to get consensus on the actual process flow, next to identify relevant metrics, such as times and costs involved, denote problems and improvement suggestions and finally to develop a future (desired) state of the process. We consider VSM as a rational coping mechanism, given its focus on empowering people to address problems at the work floor. However, in order to address work-stress problems, we need to assure that these problems can be observed in actual processes at the work floor.

Reports on the actual usage of value stream mapping in professional service operations are not available. Many papers that include cases report on the usage in production and distribution contexts. This raises the question whether the method needs to be modified in order to be applicable in the context of professional services, such as education. This study explores this question by developing and validating a value stream mapping method for education, denoted as VSM4EDU.

The structure of the paper is as follows. The next section describes the context of the study and formulates the main research question and research process. The third section describes the research methodology of the study. The fourth section describes the development of the VSM4EDU method. The fifth section describes its application in primary education and the substantive results of the research cycles. The sixth section discusses the effect of decisions made during the action research project on the final design of the VSM4EDU method. The paper ends with conclusions, implications, limitations and future research suggestions.

2. Context, problem and approach

The application of value stream mapping in education is rather uncommon. Only a few examples of its application have been described in the academic literature, e.g., Alp (2001), Narayanamurthy *et al.* (2017). Literature on value stream mapping (see, e.g. Duggan, 2013; Keyte and Locher, 2016) is rather technical and includes terminology and standardized visual symbols that are very useful to model transportation, storage, material handling, distribution and complex industrial service processes but not so useful to model processes in other sectors. The language field of industrial processes does not fit well with other areas such as education (Forno *et al.*, 2014) and other professional services.

This is not to say that value stream mapping cannot be a useful tool to describe and improve processes in an educational setting. However, before being able to use it in such a context, the tool should undergo a transformation to become more generic, suitable for other areas as well. An example of a process in an educational context that might be difficult to describe using traditional industry-based VSM symbols is learning. Learning is an iterative and social interactive process, of which the outcome is difficult to predict as it depends on

contextual factors such as the learning environment and conditional factors such as the possibility to build upon previously gained knowledge reference models, whether an urgent challenge is perceived, etc. The difference between surface learning and deep learning (see, e.g. Biggs and Tang, 2011) is described in terms of the level of engagement of the actors with the learning activity, not in terms of the time spend in an activity, the sequence of steps or the availability of support materials. The latter are typical factors that are included in an industrial value stream mapping approach.

Other processes in an educational setting might seem more similar to industrial processes. This holds certainly true for typical back-office processes, such as administrative tasks, cleaning tasks and bureaucratic processes such as reporting, material procurement and planning. For these processes, however, it may still be the case that users not familiar to industrial contexts have problems in seeing the value and correct interpretation of symbols that describe elements of these processes.

Value stream mapping is generally seen as a tool at the heart of the Toyota Production System (see, e.g. Psomas and Antony, 2019; Rüttimann and Stöckli, 2016), but according to Baudin (2013) the term has never been used or taught at Toyota itself. Womack and Jones came up with the term value stream, and in their book Lean Thinking (Womack and Jones, 1996) they suggested the readers to map the value stream, without providing a detailed how-to description. It took until 1999 before this was described in a book: Rother and Shook (1999). John Shook mentions in this book that at Toyota it was a regular practice to provide process maps or materials and information flow diagrams to depict the current and future processes. It was not a standardized method and neither used to guide the improvement process. However, it has developed into a very important method in current lean operations and its continuous improvement cycle (Womack, 2006).

The basic elements of value stream mapping are:

(1) Map

- Focus on process steps and their connections instead of single operations;
- A single mapping of both material flows (transformation process) and information flows (flow control) that are used to produce value to the customer;
- Standardized symbols to distinguish types of processes, delays, material flows, actors, information sources and information flows aimed to control the process;
- Multiple layers, e.g. to distinguish control and process flow;
- Metrics per step in the value stream;

(2) Process of mapping

- A map to depict the current actual process and another map to depict the proposed major changes in future;
- Clear boundaries for process description (customer, supplier, process start and process completion);
- Visualization in order to create overview, identify problem areas as well as solution areas that eliminate waste in quality, time and/or cost;
- Constructed by multi-disciplinary teams with tasks and responsibilities in the actual operation of the process;
- Based on observations and measurements in actual process execution.

All these basic elements need to be reconsidered in order to answer our main research question:

How can a Value Stream Mapping approach be useful in an educational setting?

To investigate whether and how an adaptation of a lean method such as VSM can be useful in an educational setting and in order to enable generalization, we need to identify a rather generic problem area in education that is in need of improvement. This problem area should be experienced by various levels of education (primary schools, secondary schools, etc) and not consider a local problem restricted to specific employees in order to allow for a multi-disciplinary approach. We have found such a problem area in the high work stress amongst teachers and other employees in education. This problem area will now be discussed.

2.1 Work stress in education

Teacher stress is defined as "a response syndrome of negative effects (such as anger or depression) resulting from the teacher's job" (Kyriacou and Sutcliffe, 1978, p. 159). Teachers of primary education experience higher levels of stress than teachers of secondary education. Chan *et al.* (2010) suggest that this higher perceived stress level could be the result of career instability due to related issues of class cuts and surplus teacher. Antoniou *et al.* (2013) found that changes and reforms in the primary education system cause negative emotions and stress more than in the past. This is in line with the result that levels of depersonalization and emotional exhaustion are more prevalent among primary school teachers than among secondary school teachers (Izgar, 2003).

According to Chan *et al.* (2010), teachers in primary education report as most important factor for work stress their heavy workload and time pressure (mentioned by 95.6% of the respondents), followed by education reforms (87.5%), external school reviews (71.4%) and pursuing further education (69.7%). Richards (2012) surveyed more than 1,200 K-12 teachers in the USA and found the following five main factors: insufficient support for needy students, workload and over commitment, lack of control over school decisions, lack of pupils' motivation to learn and feeling constant pressure to be accountable. These lists of self-reported work stressors show that teachers primarily point to external factors that are not within their own control, hence work stress is perceived as not being solvable by teachers themselves. This is an unhealthy situation as it is known that teachers not in control of their work stress may be exposed to absenteeism or burnout, which will have a negative impact on themselves as well as their pupils (Guglielmi and Tatrow, 2008; Kyriacou, 1987).

Work stress can be considered as an individual response to specific job characteristics. Hackman and Oldham (1976) presented the job characteristics model that views individual responses such as absenteeism or satisfaction as a function of job characteristics such as skill variety, task significance, task identity, feedback and autonomy, moderated by individual characteristics. The model does not explain work stress. The latter is central in Karaseks' demand–control model (Karasek, 1979). This model postulates that it is not the high level of job demands in itself that causes work stress but a lack of job control (or job resources/buffers) (Bakker *et al.*, 2008) and/or the lack of a supportive environment (colleagues, management) (Karasek and Theorell, 1990). Literature therefore points to several important aspects of job characteristics in the content (job demands), context (dependency on and support of environment) and control (autonomy, resources) of the job that explain work stress.

Work-stress generating tasks should not be analysed on its own but as part of work processes. In order to improve these processes and address work stress, an operations approach distinguishes between preparatory activities, execution activities and control activities. Support for these activities can be provided through organizational structure

(i.e., policies, budgets), colleagues (cooperation, training), machines and tools (including ICT) and individual routines (e.g., skills) (Shingo, 1989).

2.2 Research approach

This research has two aims. First, we would like to develop a VSM for education approach. Next, we would like to validate this new VSM approach in an actual educational problem setting of works stress and see whether and how it enables participants to improve processes that generate work stress.

Figure 1 shows the two-stage research process. The first stage involves a redesign of the traditional VSM approach, based on diagnosis and a literature review. For this first stage, we have developed a conceptual model for redesigning a VSM approach to make it applicable in education: VSM4EDU (Figure 2). This stage results in a proposal on how the VSM tool/methodology can be applied in an educational context: layers to be included, symbols to be used, etc. The second stage involves the validation of the redesigned VSM approach through an action-based research project to reduce work stress in an educational setting. This second stage is an empirical stage that will result in improvements in processes that now experience work stress as well as improvements in the initial redesign of the VSM approach for education. For the work-stress reduction study, another conceptual model (Figure 3) has been developed that relates work stress in processes to well-known characteristics of jobs, as described before.

3. Research methodology

The two stages of this research project require different research methodologies. The first stage requires an extensive literature review of value stream mapping in the context of education to develop a new VSM4EDU approach (phase 1, see Section 4). The second stage

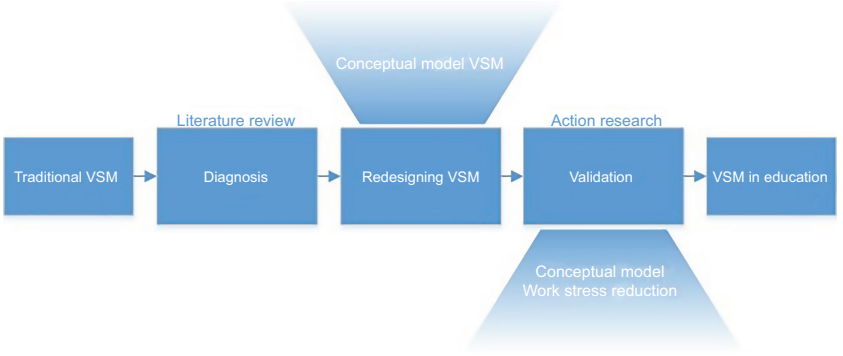

Figure 1.
Research process model

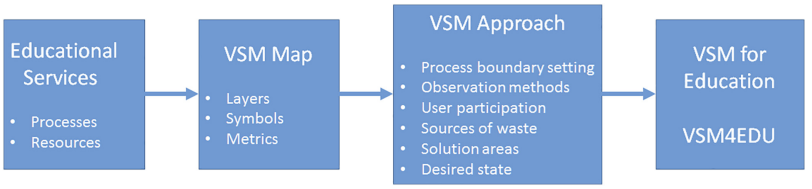

Figure 2.
Conceptual model VSM of all aspects covered in the redesign for VSM4EDU

focuses on validation and redesign and involves action research as the main research methodology (phase 2, see Section 5). Here, we will elaborate on how we use these research methodologies. While describing the narrative of the research that led to our results, we will provide some further details.

3.1 Literature research

The literature review has examined mainly papers published in reviewed scholarly journals in order to assure that the texts include a reflection on the use of the tool. We used the Web of Science database to search for papers. Keywords used for the literature research were "Value Stream" in combination with teacher, school or education. The years from 2000 onward have been used as the term "Value Stream Mapping" has been coined first in 1999. The papers have been selected based on whether they report on the application of VSM in an educational setting. Based on the 17 papers we found, we have identified references to proceedings or book chapters in which cases have been described. The total set that we found includes 24 papers, but not all papers were useful for further analysis.

3.2 Action research

We apply action research with participative design to describe and reflect on the steps taken to validate the use of VSM4EDU by a team of teachers of primary education as a rational coping mechanism in order to identify possibilities to reduce their work stress. Action research with participative design is a well-known method for research (Altrichter *et al.*, 2005; Coughlan and Coghlan, 2002). It is a quite intensive research method of the social sciences in which the researcher is actively involved in resolving a relevant practical problem while at the same time reflecting on the research process and the role of the researcher itself. A cyclical stepwise approach (construct, planning action, taking action, evaluating action) makes it possible to distinguish the various roles and provide outcomes that are scientifically useful and not just practically relevant.

The research has started with selecting an action research team that would be involved in workshops focused at visualizing processes in which they experienced work stress. The action research team consisted of both academic researchers and primary education professionals (see Figure 4). The researchers altered between roles of team member, facilitator and observer throughout the research. The workshop group participated in all workshops and was composed of five educational professionals: three teachers, one educational specialist and the principal. Two of them were male, three female, and their ages were between 30 and 60. Their level of experience in education was extensive as all participants had been working in the field of education since they started their career. Some had worked in various schools. The term "workshop group" refers to this multi-disciplinary team of educational professionals without experience with action research or value stream mapping. The term "researchers" is used for researchers in their role as facilitator or observer, both with respect to the usage and validation of the tool VSM4EDU. Finally, the term "action research team" or "team" is used for the whole group of researchers and educational professionals.

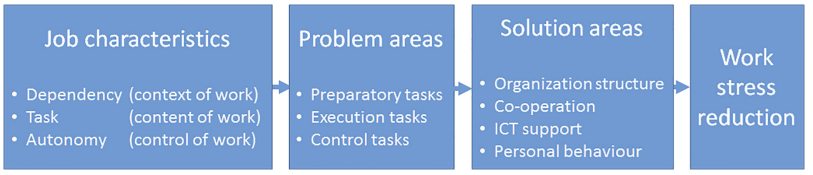

Figure 3.
Conceptual model
Work stress reduction

4. Towards a VSM for education: VSM4EDU

Value stream mapping (VSM) is one of the tools within the family of lean visualization methods, to which also process management (Parry and Turner, 2006) and shop floor control methods (Riezebos, 2018) belong. A recent cross-sector study on the application of value stream mapping (Shou *et al.*, 2017) revealed that the large majority of applications is found in manufacturing, with health sector and construction as runners up, leaving product development and service at the end of the tail of VSM usage. They do not report on cases in education that use VSM, but Douglas *et al.* (2015) do mention the use of value stream mapping to identify waste in processes within higher education institutes. Riezebos (2016) reports on a VSM approach used in a Norwegian school for primary education.

In order to learn on the use of value stream mapping, we best look at the main application area in manufacturing. Automotive industry is a well-researched area (see, e.g. Samuel *et al.*, 2015). Parry and Turner (2006) describe several cases from the aerospace industry. Reviews of VSM applications are available as well: see, e.g. Meudt *et al.* (2017), Romero and Arce (2017), Shou *et al.* (2017). The main lesson for the application area is that the employees that have to construct and use the value stream map should be trained to become familiar with the map and its symbols. The map consists of several layers, flows, data boxes and symbols. It becomes rather complex in case of more variety at the shop floor. Software tools may be used to depict the various maps and support the process of modifying the map due to new inputs of participants. However, this software may look complex as well. For example, Visio offers a value stream mapping template with 29 predefined symbols (five more than suggested by Rother and Shook (1999)), including kanban boards, supermarkets, transportation, etc . This list can even easily be extended with more shapes. Hence, software may simplify part of the mapping process but at the other hand complicate it as well. For the interaction amongst participants, a simple pen and paper–style approach might be more effective to organize interaction, facilitate discussion and remove the focus from tools to results.

For specific industries, new symbols have been introduced to support the process of mapping. For example, Villarreal (2012) has developed an extended list of symbols and approaches for the transportation industry. Similar modifications have been suggested for health care sector (Henrique *et al.*, 2016), public services (Radnor and Boaden, 2008) and hotel sector (Vlachos and Bogdanovic, 2013).

Many of the symbols for using VSM in these sectors are rather complex or detailed. This is not useful for a team of teachers in an educational setting. They are well educated but have no background in either process thinking or mapping, no time for extensive lean training and no familiarity with continuous improvement methods. We therefore have developed a simplified value stream mapping approach in the educational context. The method should be useful as a tool in educational process improvement. A first step is the introduction of a limited set of standardized visual symbols to be used in the mappings. We propose to use a map-structure consisting of three layers:

(1) Control layer (supplier, client and internal controllers and control systems);

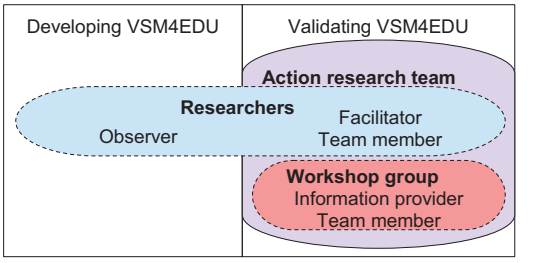

Figure 4.
Participant roles in the research project

(2) Process layer (start, finish, activities, dependencies);

(3) Observation layer (measurements, disturbances, problems). See Figure 5.

We also propose to use far less specific symbols to distinguish and characterize activities at the process layer than is usually done in value stream mapping (10 instead of 24 or more). However, the basic content is still there, with emphasis on the process flow in which value is being delivered and the connection with the information flow that initiates, monitors and controls the process. The main reason for the smaller number of symbols is that it requires more training to read and construct more detailed process maps. In the educational context, training of employees in such a technique is limited due to time constraints. The observation layer includes both quantitative and qualitative observations of the process and its control. This means that we propose less emphasis on detailed data gathering as part of the mapping process and more explicit opportunities to identify problems and disturbances during the mapping process. At the other hand, by introducing symbols to depict those disturbances and problems, we urge the team not to discuss these problems in detail during the mapping process but just depict on the map what they observe in order to open it up for discussion with other stakeholders in a later stage.

To conclude, we propose a VSM4EDU approach that simplifies the map structure and symbols in order to make it applicable for teams in an educational context that have not received extensive training in lean thinking, problem solving and value stream mapping.

5. Investigating work stress using VSM4EDU

In this section, we describe the steps taken to validate the VSM4EDU approach. Team decomposition has already been discussed in section 3, so we start with the team helping to identify and select processes related to the main improvement area that they had chosen: reducing work stress. Next, we describe what observations are necessary and how we accomplished this in an action research setting. Finally, we describe how to use the VSM4EDU method in workshops to map and improve the work-stress related processes.

5.1 Identification and selection of work stress–generating processes

Lean schools aim to engage the people involved in the process to examine and improve the process as well (Riezebos, 2016). In order to address work stress among teachers, it is therefore essential to involve teachers and have them analyse what processes actually cause work stress and might be useful to analyse. However, in order to build an improvement culture, we did not directly start with investigating what improvements were needed but first

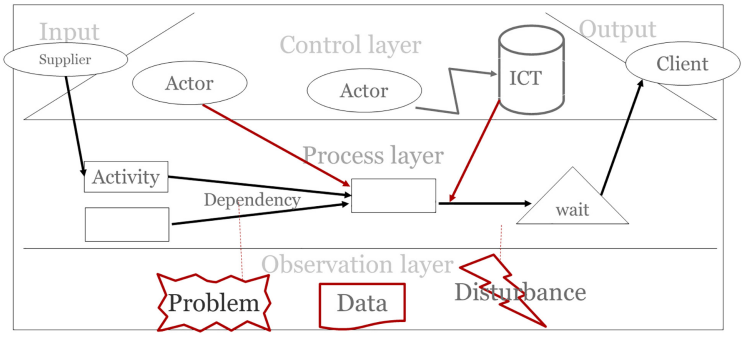

Figure 5.
VSM4EDU value stream map for education: structure and symbols

gave attention to the group identity and shared goals. In a brainstorming session, the workshop group members were asked to discuss what they think is going well or what they are proud of in their school. They appreciated the atmosphere, contacts with colleagues and parents, structure and care for children and the good name of the school. Based on this shared understanding, we asked what work-stress generating processes needed improvement to further develop this shared identity.

The researchers developed two mechanisms to select processes for the value stream mapping approach. First, a matrix to depict the cost and benefits of improving the process (see Figure 6). The horizontal axis describes the benefit (expressed in whether the process adds value), while the vertical axis describes the costs (expressed in time spent in this process). Processes that are valuable but currently take up a lot of time are deemed best for an improvement project using VSM4EDU. Processes that are located in the other three quadrants can either be ignored or eliminated or should be used to learn from. They do not require a value stream mapping approach.

Second, the processes are scored on process frequency and origins of work pressure, being dependency, task content and autonomy. This step is accomplished mainly for methodological reasons as it is essential for the validation of VSM4EDU to be able to observe actual processes that cover a wide range of work-stress issues. *Frequency* refers to the number of times this process is repeated. Processes with a higher frequency (daily or weekly) are more relevant to improve as the effect on work stress reduction will be experienced more often. Moreover, it would be possible to actually observe these processes within the time span of the study. The three origins of work stress have been described in the literature section 2. *Dependency* is a context factor and refers to work pressure resulting from dependency on others, including co-workers, inspection, government or students' parents. *Task content* refers to the actual task requirements influencing work pressure, and *autonomy* is the control factor that describes a person's autonomy in conducting and monitoring the task. By selecting a set of processes that covers all three origins of work stress, the study is more representative.

After the action research team agreed on which processes to focus, team member role(s) were assigned. The three teachers each volunteered to be observed for one of the processes.

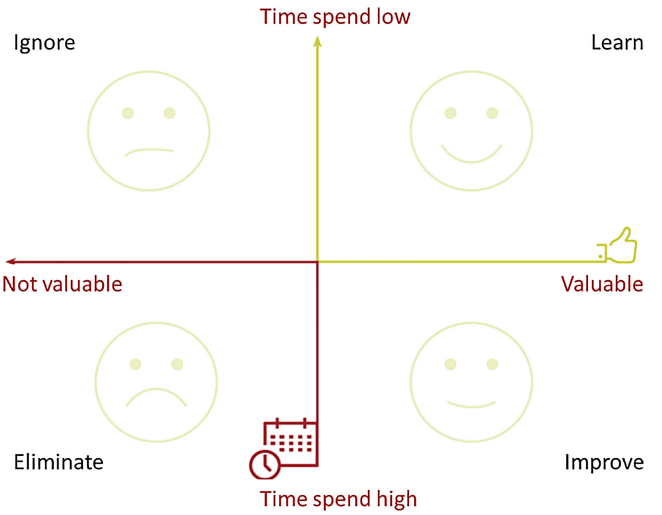

Figure 6.
Process selection for value stream mapping: process value versus time saving

The principal and the educational specialist would provide supporting information and documentation and participate in the mapping of the value stream. The principal would also act as information provider to people external to the action research team (i.e., other colleagues).

5.2 Observation of work stress–generating processes

The observation of the selected processes was accomplished by two methods: videotaping and audio recording. Two processes were videotaped in the regular workplace of the teacher while the process was executed (i.e. in their school classroom). They were asked to explain all of their actions during the execution of the entire process. The last teacher accomplished a task in-class, engaging with the pupils and monitoring their progress. Videotaping would interfere with this process. Hence, it was decided to make an audio recording of the session and photographs of critical situations that occurred.

The observations have been transcribed, and we asked for other relevant documents of the process, e.g., materials from the pedagogical methods used, background information from inspection, national teaching outlines, individual teaching plans and assessment schemes.

5.3 Value stream mapping to analyse work stress–generating processes

The first two selected processes were addressed during three work group meetings of 1.5 h each. During these meetings, the facilitator provided a basic introduction of the methods and symbols, while the other researchers observed the work group discussion and output, in order to understand whether VSM4EDU was helpful in guiding their improvement process. The facilitator showed pre-selected fragments of the video, while the observed teacher explained what he or she was doing. The third selected process was addressed during a single meeting of 2 h, including an evaluation of the whole approach, in order to see whether the work group members were able to apply all phases of the VSM4EDU approach in a single workgroup meeting. This type of meetings is also denoted as a Kaizen event (Glover *et al.*, 2013).

The teacher that was observed for a process was present to answer questions of the other work group members but was not involved in actually depicting the value stream map. As the processes were relevant for all teachers at this school, the resulting map was shared with the whole school team in order to gather feedback and input from them as well. We used the staff room to put the map on the wall, accompanied with forms to gather feedback or comments. In the next work group meeting, the value stream map was updated based on these comments. The next step was to add measurements (task length, waiting times, etc), identify problems and structure these problems. The problems were classified into three categories: preparation, execution or inspection. Problems in the category preparation refer to activities that should have taken place in order to facilitate the current activity. Execution problems pop up during the execution of the task but could not have been avoided by a better preparation. Inspection problems refer to the evaluation of the task, i.e. how to know whether it has been accomplished correctly or not. During the workshops, we replaced the term inspection with reflection/evaluation as inspection was associated with the formal inspection audits of government in the field of education.

5.4 Generating and evaluating solutions to work stress–generating processes

The next step in the workshop was to identify possible solutions for these problems. All participants were asked to think of possible solutions for each of the problems and to allocate these solutions in a matrix with four types of solutions, as described in our literature review: organizational structure (i.e., policies, budgets), colleagues (cooperation, training), ICT (i.e., machines and tools) and individual routines (e.g., skills). This matrix could be extended if they

had identified a solution that would not fit in one of these categories. During the meeting, the problems of all three categories (preparation, execution and inspection) were examined. After the meeting, other members of the school team were invited to bring forward ideas for solutions as well. The matrix was finalized in the next meeting. The total list of solutions was then prioritized by the participants based on impact and expected efforts to realize the solution. One of the teachers took leadership in communicating the list of solutions to the other members of the school team, not by using a new value stream map but by a visual representation of the solutions themselves. Many of the solutions communicated better through such a simple visualization. Moreover, ownership of the solution list was clear to everyone in the school.

6. Results

This section presents the main findings of the empirical phase of this research project, i.e., the action research project where VSM4EDU is used to address work stress. It also addresses the validation of the VSM4EDU approach.

6.1 Identification and selection of work stress–generating processes

Group identity and shared goals were investigated in a brainstorming session. This resulted in 11 positive characteristics that make them proud in their school (see Figure 7). One work group member stated: "*I thought we were only going to talk about what's bad, but it is also good to realize that we are actually doing quite well*". Next, the group discussed processes that increased their work stress. This resulted in a list of 13 work stress–causing processes (see the legend of Figure 8). Each member of the workgroup placed these 13 processes in the

Figure 7.
Aspects that make employees proud of the school

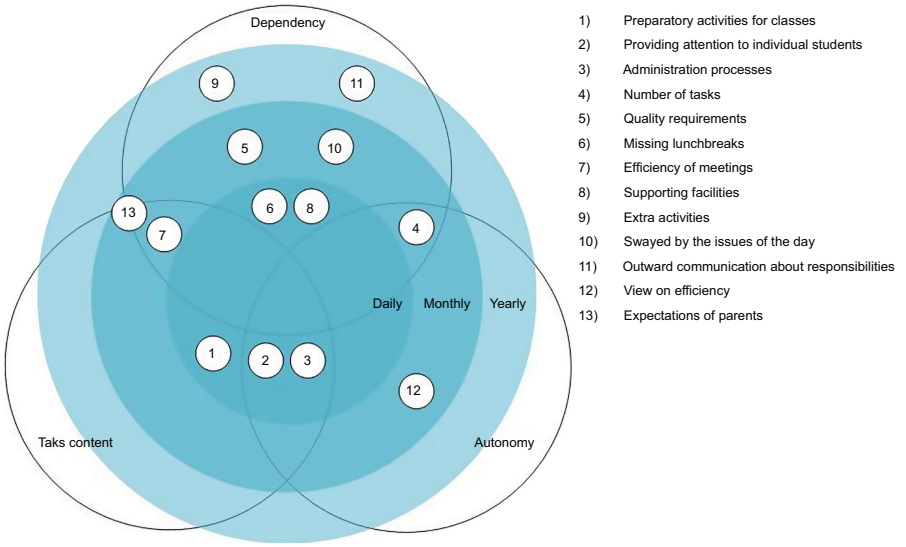

Figure 8.
Categorization of work stress–generating tasks in education

matrix of Figure 6 (process value versus time spend on process). "Preparatory activities for classes", "providing attention to individual students" and "administration processes" have high value and need a lot of time. These three tasks are candidates to improve. "Quality requirements" and "supporting facilities" provide value while requiring average time, so these are somewhat in between improve and learn. No processes were found to be of low value and much time needed, while only one process belonged to the category Ignore.

Next, processes were classified based on origin of work pressure and process frequency. The three processes for improvement were deemed useful for the research project as they would be observable during the timeframe of the project and covered two types of work stress causes. Dependency (context) as a cause for work stress was not included, mainly because it was important for the team to be able to suggest and implement solutions themselves. The selected processes relate to coping with increased variety, long and uncertain throughput times and unclear specifications of processes. This has consequences for the preparatory activities for classes (process 1) as well as providing in-class attention to individual students (process 2). Next, the unclear specifications and handling of administration processes show the need for improved standard operation procedures supported by appropriate ICT facilities (process 3). In all processes, a returning factor is the reliance on external resources and the long and uncertain throughput times of requests for ICT support. This shows that boundary control and communication are essential instruments in coping with work stress.

6.2 Value stream mapping to analyse work stress–generating processes

The first process that the team selected to investigate concerns an administrative process that each teacher has to complete at least twice a year. They have to determine a group plan for four domains (e.g., language, calculus) based on the progress the individual pupils in their year group have achieved. In the group plan, the teacher formulates focus goals and method goals for the next term. These goals can be formulated for the group as a whole or for several subgroups or even individual students. That high level of detail is in general not necessary. For each pupil they have access to individual scores in the national testing service, scores according to the method they use in class and to previous plans as well as other relevant

information. These scores have been analysed already, but the follow-up actions still have to be planned. Method goals are strongly related to the method used for a specific domain (e.g., calculation or pronunciation) and may be formulated in terms of the average score aimed at for each subgroup that has been distinguished. Individual pupils are assigned to these subgroups. Focus goals are related to common patterns of the group as a whole in this specific domain (e.g., punctuation), perhaps due to a change of methods in a previous year or cultural issues. After setting the goals, the teacher has to determine appropriate pathways to achieve these goals, for example, by selecting additional materials or projects.

The teacher who volunteered for the observation of this process explained that for developing these four group domain plans they have four to five weeks of time, but in the last two/three years he is always lagging behind, which causes work stress. He postponed these tasks to evenings, weekends or holidays. This is neither satisfying. He stated: "*I'd like to stop working overtime, as the last ten years this has been the case: every evening still busy with school*".

The time he expects to need to prepare a group domain plan is 1.5 h. The actual time needed for the various process steps depends very much on where the process is accomplished (at home or in the school), due to factors such as network access to data, formal documents and the occurrence of disturbances and distractions.

We asked the other members of the workshop group to depict the process they observed in the video fragments in a map (process layer), identify actors and systems used (control layer) and list disturbances, problems and metrics in the observation layer. See Figure 9 for the resulting value stream map. The interaction between the observed teacher and the other members of the workshop group was very important in this mapping process. The facilitator assured that the interaction was goal-oriented and that it was respectful for all. Problems that were identified when watching the video were put on a flip-over in order to prevent an extensive discussion of the reasons behind the process at that moment in time and focus on what actually occurred. One of the workshop members (not one of the teachers) reported: "*I had never envisioned that not knowing when input is concrete and detailed enough would cause teachers so much stress and costs them so much time.*"

The mapping process took one hour (including watching the video fragments and asking questions). It is a factual description of the sequence the teacher used in performing the tasks. We omitted the time metrics in the VSM of Figure 9 to provide overview, although this information could easily be observed using the timeline of the video.

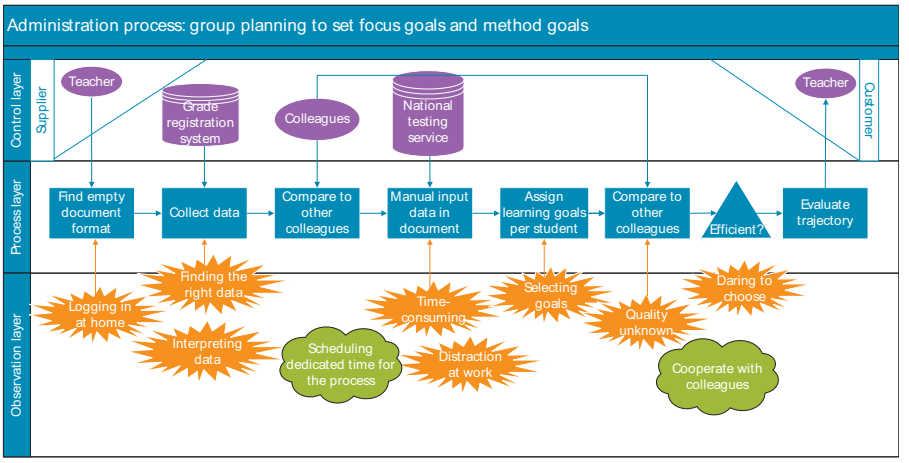

Figure 9.
Using VSM4EDU to map the selected administrative process

Next step was to share this map with the other teaching staff in the school and gather input of missing steps, information sources or problems. In the next workshop, we continued with the analysis of this map and the problems in the current process. First, we analysed the cause of the identified problems: was it due to issues in preparation, execution or inspecting the output of the task? Next, for each problem and its main cause, the workshop members identified a solution and allocated this solution in a category: organizational structure, colleagues, ICT and individual routines. Based on this categorization, they finally came up with a top list of solutions to tackle the work stress associated with this specific process. Their top list consisted of five actions: (1) schedule and facilitate regular meetings for teachers that would like to work along on their group plans; (2) improve the transfer of knowledge between last years' and current teacher of a group; (3) improve the template for the group plan by using simple schemes and predetermined lists from which a teacher can choose instead of having to find an adequate formulation themselves; (4) improve accessibility and sorting of the various data sources; (5) more team work and sharing instead of being left alone with individual tasks. Solution 1 belongs to organizational structure (policy), while 2 + 5 belong to colleagues and 3 + 4 to ICT. One of the workshop group members reported: "*By better team work and support while teachers work at their plans, we could easily prevent this type of work stress and loss of time.*" The action list was presented by one of the teachers to the whole staff.

The same procedure has been applied for the other two selected processes. The resulting value stream maps and solutions are available upon request. The main differences are that the disturbance symbol has been used in these maps and that the team was able to speed up drawing the maps, which left more time for the analysis. The solutions in terms of work-stress reduction for these two processes were distributed over all categories, with a lot of attention for organisational structure and co-operation in the team. However, there were some differences between the processes. The first process (preparatory activities for classes) could clearly benefit from better ICT support, but the teachers noticed that this would require investments not just in hardware (tablets) but also in training, support and maintenance during the usage phase. The latter process (providing attention to individual pupils during class) gave much less attention to co-operation and ICT while putting more emphasis on solutions in the personal domain of the teacher. Examples are: visualizing communication and rules in the class room, install timer on the electronic white board, distinguish more clearly between various support modes available to pupils during class and finally being more predictable as a teacher when to offer what type of support.

6.3 Validation of the VSM4EDU method

For validation, we evaluate the variables of educational Services (processes and resources), the VSM map (layers, symbols, metrics) and the VSM approach, as listed in the conceptual model of Figure 2.

Educational services are part of the field of professional services. The language field of this type of organization differs strongly from industrial and mass service environments. However, it is still possible to distinguish between processes and resources active in or required for these processes. The use of a process-oriented mapping method such as VSM4EDU draws attention to the processes itself instead of just focussing on the (lack of) resources. Processes describe how value is provided to the client, so they are goal-oriented. Resources contribute and constrain the execution of processes. Hence, a focus on resources brings along a focus on limitations, costs and efficiency. By using VSM4EDU, we have actually observed a change in perspective among the participating staff members. Instead of focussing on their work stress itself and the causes that were out of their control, they started to focus on their shared goals and the associated processes. Hence, we conclude that it is possible to change towards a process orientation in a professional service environment that is not familiar with the jargon and approach of operations management. This is supported by

one of the participants, who said "By simply following and visualizing the process that we executed, possibilities to improve became apparent and we have been able to realize real improvements."

The team was quickly used to the three layers of the map. Rother and Shook (1999) did not distinguish these layers but just suggested a sequence for drawing the map (starting with identifying the client, next the processing steps with all relevant data and finally depicting the material flow and information flows). With respect to the symbols, most symbols have been used, although the disturbance symbol was only used in the second and third map and the data symbol was not included at all. The team added an "idea" symbol in the observation layer. Such a symbol would normally not be used in a VSM map of the current state, but in the process of identifying problems, ideas and suggestions came up as well, hence the team depicted them on the map. We think this shows how the method can be easily adapted by a lean team in education. The only metric that was explicitly used while applying VSM4EDU was related to the timeline in the video. We conclude that the map construction in VSM4EDU is useful for this professional service environment.

The VSM approach in VSM4EDU exists of process boundary setting, observations, user participation, identification of waste and solutions and proposing the desired state. Process boundary setting is known to be a problematic issue in VSM projects (Riezebos, 2016), but in this action research project it was not, due to the fact that teachers themselves proposed to examine their process and we limited the analysis to the start and completion of the process in the video. Hence, the observation methods help to see or hear what actually happens in the process, and the explanation provided during and after the observation gives relevant background information on the problems encountered while executing the process. User participation is essential in VSM4EDU. Team composition and building a safe environment for such an improvement approach are therefore crucial. VSM4EDU is a non-hierarchical multi-disciplinary improvement method based on principles of transparency and respect for people. The identification of problem areas (waste) and solution areas is part of the approach. The structure VSM4EDU provides (characterizing the source of problems and type of solutions) helped the team to identify possible solutions for all problems they found. Finally, the team decided to not draw a future state map, as is usually done in a VSM approach, but to focus on a top list of solutions and present them on a slide in the staff room. Their idea was that this improves the ownership of the future state as the teacher that presents the list will informally be considered responsible for the implementation.

6.4 Evaluation

The enthusiasm of the team for this improvement approach has grown during the weeks of using the method. The time they had to invest was limited to the five meetings of 1.5 h each, which was important as the problem they investigated concerned work stress, hence the solution method needed to limit the time they had to spend on it and bring forward a good return on their investment. They liked the structured approach, where the method was leading in what to do and how to analyse it and where they themselves were leading in identifying problems and solutions.

Four months after finishing the project the researchers returned to the school to find out how they evaluate our main research question: can value stream mapping be useful in an educational setting. All workshop participants contributed in the discussion and were still enthusiastic. They appreciated the main difference between running daily operations, where team members just work in isolation and the VSM4EDU improvement approach, where they worked as a team to help each other improve processes and reduce work stress.

The roles of the action researchers were focussed on clarifying the terminology and tasks in the value stream mapping approach, performing the observation studies, selecting the

video fragments for use in the workshops, facilitating the workshops and reflecting on the elements of VSM4EDU.

7. Conclusion

This study has examined how a value stream mapping approach can be of use in an educational setting. Based on literature research we have concluded that the VSM approach as described in literature needs to be adapted in order to be useful in professional service organizations such as education. We have developed a modified approach, denoted as VSM4EDU. The main differences compared to traditional value stream mapping are found in both the map and the approach. The map in VSM4EDU is better structured, uses far less symbols and gives more attention to non-quantitative observations, such as problems, disturbances and ideas. The approach suggests specific observation methods that help to prevent typical problems in traditional value stream mapping projects in the field of boundary setting. Moreover, the VSM4EDU approach proposes a structured way of analysing problems and identifying solutions. Finally, the ownership of the final solution is clearly assigned to one of the team members. We conclude that teams of teachers have been able to develop rational coping strategies to reduce work-related stress using VSM4EDU. Moreover, the participants were motivated to work as a multi-disciplinary improvement team, starting with understanding the actual process, analysing the sources of problems and suggesting improvements.

The team used VSM4EDU to identify, select and address processes that, according to their perception, generated work stress. The solutions they presented to the rest of the school team were within their reach to implement on a short term, i.e. very practical and not depending on high investments or decision making by authorities. Even the ICT suggestions were rather easy to implement as it concerned the sharing of additional materials and notes between colleagues on learning methods the school is using, the location where information on last years performance of pupils is stored, etc. This shows that these work stress–generating processes can be addressed without major investments in budget or time using a VSM4EDU approach.

Managerial implications of this research are that lean methods, such as value stream mapping, are not limited to industrial production or mass service areas but can be very useful in professional service environments such as education. The methods may need some adaption in order to bridge the gap between the application areas, but most important is the change of perspective of the people involved. Instead of focussing on external causes of problems they face, managers would have to empower people to develop rational coping strategies and use structured methods such as VSM4EDU to help people implement these strategies.

The scientific contribution of this study is the well-documented and validated application of value stream mapping in an educational setting. Based on an extensive literature research, an adaption of traditional VSM has been suggested: VSM4EDU. The validation has been accomplished using action research, which provides deep insights in how a team of teachers and other staff members have been using the suggested approach.

Future research could extend this study to other fields of education. We examined a relatively small school for primary education. Larger schools might develop different approaches for communicating solutions, taking ownership or analysing repetitive processes. Moreover, in schools for secondary, vocational or higher education, this approach has not yet been tested.

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