# Agile Engineering
## Introduction of a new Management Concept

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**Summary**

Research questions: Is it feasible to apply Agile Project Management methods known from the area of software development to general and project management tasks in engineering? Doing so, is it possible to increase employee motivation and engagement?

Methods: A decision criterion, the Agile Application Map, has been derived supporting the selection of the adequate management approach. Two different surveys have been conducted following two prototype projects. The first one has been performed in the area of general management, the second one in project management.

Results: Clearly positive results in the field of motivation and engagement could be realized. Even though there is also scepticism towards new management methods in the traditional engineering environment.

Structure of the article: 1. Introduction; 2. Agile Engineering and Scrum; 3. Agile Assessment Practices Moving Motivators; 4. Agile Application Map; 5. Hypothesis; 6. Empirical study; 7. Conclusion and Outlook; 8. References

## 1. Introduction

Today's businesses are facing several challenges, being the continued push towards reduced costs, shorter development cycles and competition for rare experts. Hence, modern managers have to ensure to deliver products in time, function and budged while keeping their workforce motivated and engaged. In order to help these challenges, this paper introduces a new management approach applying elements from Agile Software development to general management tasks out of the mechanical engineering environment. This set of methods has been identified as potentially beneficial as similar challenges are faced by Line Managers and Project Managers. The hypothesis to be confirmed is that employee motivation and engagement could be affected positively by choosing a different leadership style, deviating from what is currently established practice, especially in the area of mechanical engineering. The new management concept has been described as Agile Engineering and is applied and verified based on two prototype tasks within an industrial environment of an international corporation.

Main challenge, which has to be overcome is to transfer Agile project management ideas into a different business environment characterized by a noticeable

more conservative management approach and no experience existing with regard to Agile methods or Scrum.

The starting situation with regard to employee motivation and engagement can be described such that most of the employees are not very enthusiastic and over-committed to their work and that there is high risk of causing delays in projects, which might be explained by insufficient communication. Applying Agile management practices is believed to improve both, commitment and attitude of the employees, which will be measured by conducting two employee surveys while moving towards the concept of Agile Engineering.

## 2. Explanation Agile Engineering and Scrum

The concept of Agile Engineering is based on Agile development methods, which are applied for complex product development and difficult tasks mainly in software development, (Beck, et al., 2001).

First modern ideas of applying it to applications out of software development have been described by Takeuchi and Nonaka, (Takeuchi & Nonaka, 1986). Typical for projects applying Agile methods is that accurate estimates and stable plans as well as predictions are hard to realize in early stages of the project. From a structure point of view it is an adaptive, iterative and evolutionary development with milestones that even might change during project execution.

Agile practices proved to beneficially affect communication and collaboration within teams by bringing the team members in the focus of all activities, (Larman, 2004). Selection criteria for going Agile can be found for example according to (Sliger & Broderick, 2008). The origin of Agile methods goes back to software development projects, whereas one of the most important elements is Scrum, (Schwaber, Agile Project Management with Scrum, 2004) and (Schwaber & Beedle, Agile Software Development with Scrum, 2002), see Figure 1, (Sen & Kolb, 2015).

In Scrum there are defined events as well as roles dedicated to the persons acting within a project. Speaking about the very basics, the following events will be introduced: Sprint and Daily Scrum, (Schwaber & Sutherland, The Scrum Guide, 2013). The Sprint is the basic unit of Scrum and is time-boxed, duration is between one week and one month. Daily Scrum is a communication meeting where all team members attend in a prepared manner. Duration is approximately fifteen minutes, whereas each team member answers three questions:

1. What has been done since yesterday?
2. What is planned for today?
3. Are there any impediments affecting the intended scope?

Other events are quite similar to what is known from general project management and do not deviate in a noticeable manner. These are planning efforts, reviews, retrospective meetings or lessons learned, (Phillips, 2003).

Scrum specific roles can be identified as the following: the Product owner is representing the stakeholders while being the voice of the customer. He or she prioritizes the work and managers the product backlog. The Scrum master is assigned to remove impediments faced by the team. This person should fully focus on the Scrum process and should challenge the team to follow the rules, (Schwaber, 2004).

Detailed description of Scrum Master duties and scope of his work are described by Sen and Kolb (2015). The development team comprises usually of three to nine individuals with cross-functional skills and operates fully self-organized. This means that in pure Scrum there is no project management role defined. Finally, external experts are consulted in case of support needed.

Besides the described events and roles several artefacts of Scrum exist, (Schwaber, 2004). The first one to be introduced is the Product backlog representing an ordered list of requirements prioritized by the product owner. Usually, this list is present in a story format illustrating scenarios the user of the software is intending. The size and complexity of each item of the product backlog is determined by the development team.

The second important backlog item is the Sprint backlog, (Schwaber, 2004), which comprises of a list of work for the next sprint. For the size of the Sprint backlog the capacity of the development team for the next Sprint is important. The Sprint backlog is owned by the development team and tasks are usually not assigned but signed up by team members. For tracking of the tasks a kind of task board or burn-down board

might be used. These show the remaining and completed work and indicate the progress of the Sprint. The tasks comprised in the Sprint backlog are broken down into hours for completion. A single task should not take longer than 12 hours or one day.

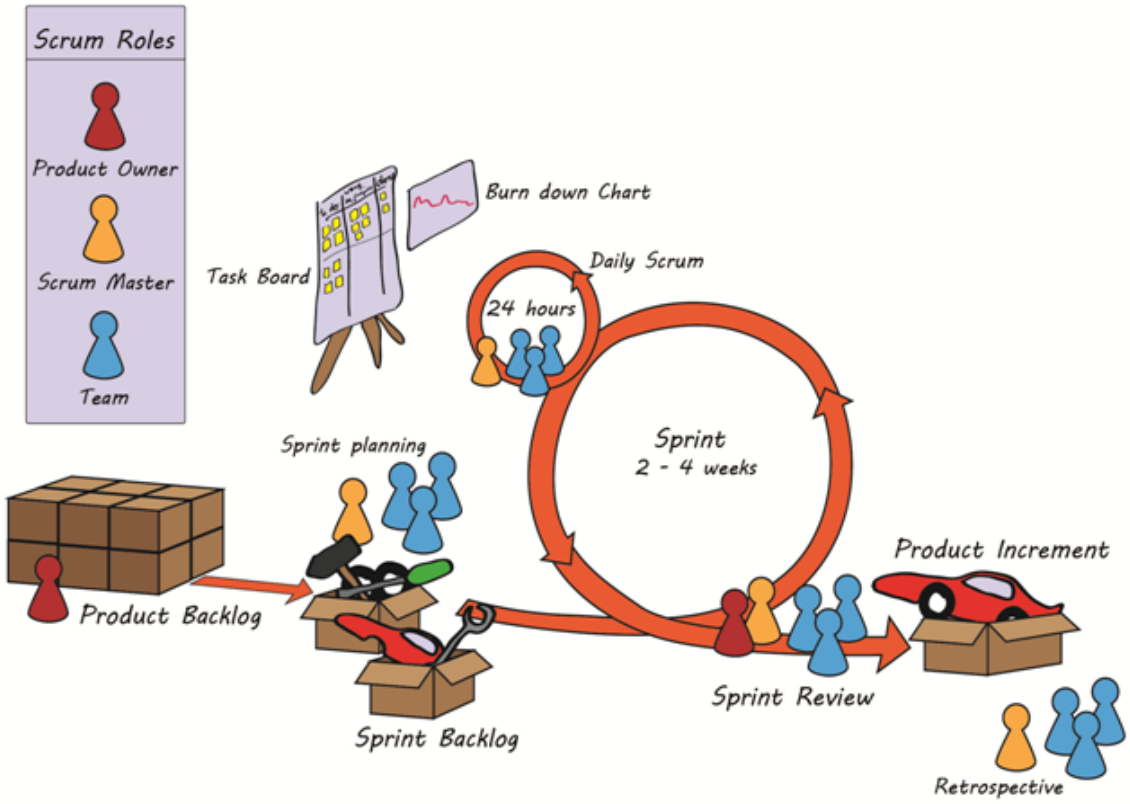


Figure 1: *Overview on Scrum approach,* (Sen & Kolb, 2015)

## 3. Agile Assessment Practices Moving Motivators

Moving Motivators are introduced as an assessment method for the impact of a change management process, which will be applied later on to rate the effects of Agile project management as applied to engineering tasks. Moving Motivators is one out of several new management tools created by a community of people initiated by Juergen Appelo and published as Management 3.0, (Appelo, 2012). The Moving Motivators as such are based on a CHAMPFROGS model of intrinsic motivation. This model has its roots in a book on basic human desires published by Steven Reiss, (Reiss, 2002). For the Moving Motivators assessment those desires have been simplified by removing basic needs like family, romance and vengeance, to make it applicable on needs driven by the business environment. Finally, some needs have been renamed. The resulting ten motivators read as follows:

1. Curiosity: I have plenty of things to investigate and to think about.
2. Honour: I feel proud that my personal values are reflected in how I work.
3. Acceptance: The people around me approve of what I do and who I am.
4. Mastery: My work challenges my competence but it is still within my abilities.
5. Power: There is enough room for me to influence what happens around me.
6. Freedom: I am independent of others with my work and my responsibilities.
7. Relatedness: I have good social contacts with the people in my work.
8. Order: There are enough rules and policies for a stable environment.
9. Goal: My purpose in life is reflected in the work that I do.

10. Status: My position is good and recognized by the people who work with me.

## 4. Introduction of the Agile Application Map

In order to apply Agile Project Management tools and procedures in an engineering environment, a new decision matrix extending the ones described by Slinger and Broderick, (Sliger & Broderick, 2008), is introduced by this paper. The idea is to propose a step-wise application of separate elements of Scrum and Agile development methods based on defined criteria. This decision matrix is called the Agile Application Map.

For the Agile Application Map two main criteria have been identified, these read as "Employee engagement levelling" and "Task complexity", see Figure 3. The criterion "Employee engagement levelling" is defined indicating to what extend the results of a certain task are depending on the level of engagement and motivation of the person executing. An example for a low indicator would be the work on a production line assembling simple products with a lower error probability. High levels describe creative work, for example the design of a new product or the development of robust designs with long lifetime. These tasks require the full attention of the person executing.

On the other hand the complexity of a task defines how easily it can be overlooked by a person involved in executing it. Simple complexity might be for example conducting simple calculation with Excel. Here, mainly input, function and output need to be defined and the desired result is obtained. On the high side of complexity, multi-disciplinary designs of products comprising of different components can be found. Examples might be the development of airplanes, aero engines and power plants, all of them need to fulfil certain aerodynamic, mechanical and interface requirements like noise and emissions.

The Agile Application map can be subdivided into a path preferably applied for Line management tasks and another one intended for project work. By assessing the Agile Application Map four different areas for project execution or general management tasks can be identified, namely a work package based approach, a mixture between work package based and incremental approach, the area of Agile communication and finally the area of Agile Engineering. In the following, the concepts behind those four management strategies are explained in more detail.

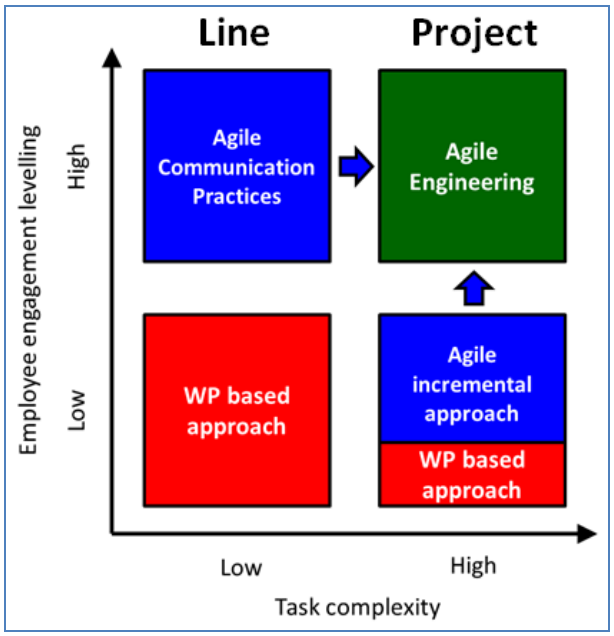


Figure 2: *Agile Application Map*

The work package based approach can be applied in an area with low complexity tasks and low values on engagement levelling. Here, a very lean management style is sufficient by just defining and distributing tasks or work packages. The people working on those might not require the creation of a big picture as the task might be isolated from other business activities. For performing their work, there is no communication framework required. All what is expected is to create results in time. This approach might be most suited for people preferring to work as an expert in a quite specific subject and with no team surrounding them. From a management complexity point of view, this represents a very simple level.

Moving on to the area characterized by still low ranks of engagement levels but high task complexity, here, a mixture between a work package based approach and Agile incremental elements is proposed. The idea behind is to collect expert input breaking down complex development tasks into smaller pieces and handling those tasks again like in the pure work package based approach. In this case, the creation of the big picture is required, in order not to lose track while working through the jobs defined. Further, time-boxing and the definition of small tasks is recommended allowing a

continuous progress without getting stuck due to the high level of complexity. In order to ensure a proper interface management, the project management should ensure regular core-team meetings.

By having a look on the area of low complexity but high engagement levelling effect, the application of Agile communication practices is recommended. The idea here is to allow information sharing as well as improving collaboration between the different people involved in the task. Everybody should feel integrated and appreciated. Further, creativity is enabled leading to new and improved solutions to design problems. Management might become more extensive compared to the work package based practices. However, it is believed that this pays off by the team being more productive. The concept of applying Agile Communication practices on a Line management tasks will be detailed in the following section 6.1.

Finally, the area with high levels on both, complexity and engagement levelling is considered. Here, the main application of the Agile Engineering concept is seen. This approach combines elements of Agile communication and the incremental approach. Following the elements as introduced in Figure 1, enables the maximization of the output of the project team, by structuring the work into small pieces and working through them. At the same time improvements are believed to be realized regarding employee engagement and motivation by integrating the team in the project planning and also the decision making. From a project management point of view this might be a more challenging concept comparing it to the traditional approach, especially, as the role of the project manager is not any longer defined. Instead there is shared responsibility between product owner, Scrum master and the project team. In the long run, it is believed that complex design tasks requiring a highly skilled and motivated workforce, which needs a certain amount of self-organization to perform in an innovative and creative way. Otherwise there is the risk of either losing productivity due to insufficient communication and interface management, or to lose motivation and engagement as employees are not feeling part of the process.

## 5. Hypothesis

The research question at hand is whether it is possible to show that Agile methods applied in an engineering environment are leading to a higher level of employee motivation. The approach to verify this is to conduct an assessment of the motivational patterns and to rate if they have improved or worsen after two case studies have been performed. The assessment method applied is the Moving Motivators exercise, (Appelo, 2012).

## 6. Empirical study

The new Agile Engineering concept has been studied in an international corporation with several ten-thousands of employees. It has been applied in a Research & Development business unit focusing on the development of complex products designed by multi-disciplinary teams. Recent employee engagement surveys indicated a drop in motivation and engagement as a result of the current management footprint. By means of the two case studies performed, it is intended to show that Agile Engineering is able to realize both, meeting challenging project targets and keeping or even increasing motivation and engagement of employees.

### 6.1 Line-Scrum - Agile Communication Practices

The background of the idea of Line-Scrum can be described as follows, when the author of this paper took over the leadership of a team of engineers, the traditional line management style has been replaced by elements of Scrum. This change has been practiced from April 2013 until September 2014 with altered intensity of Agile practices. The team applied for this study can be described as quite diverse regarding age and cultural background of the team members. All together there were six team members with an age from 23 to 62 and three different nationalities. Hence, the application of a common management style addressing the different needs of the team members is complicated.

The approach for managing the team can be described following the ScrumBut method. This means that not all elements of Scrum are applied or certain elements are used in a different way. Thereby, the focus was on applying communication and collaboration elements

offered by Scrum, while ignoring the full package of project management techniques. In detail this means that there were daily-Scrum meetings, kind of Sprint planning meetings, however, no time-boxed Sprints. Building a framework of communication and information sharing by means of a daily-Scrum was believed to improve collaboration and integration within the team. This daily update round has been held every morning and followed the standard Scrum questions to be answered, see above. The role of the group leader has been replaced by a moderator or coach during the meeting, comparable to the Scrum Master. Issues identified during the Scrum session were recorded and addressed later on.

As a kind of pre-validation of the suitability of Agile communication tools, after practicing Daily-Scrum for four months separate interviews with all team members have been hold. The feedback received was dependent on the person asked, whereas, differences were mainly correlating with the age of the employee. The results are summarized in Table 1. Young employees aged below forty years old were clearly in favour of the Scrum meeting instead of the traditional team meeting hold once a week. This group is responsible for the 50% of positive feedback. The reason has been described as being much more informed and involved in projects ongoing. From employees in their late fifties there was appreciation of the new approach. However, holding a Daily-Scrum was observed as quite challenging to report on continuous updates and improvements. These colleagues felt slightly put under pressure and might have experienced the Scrum meeting as a kind of control instrument to check their performance. The rating of being sceptical towards the new approach is given by this group. Finally, the neutral feedback was given by one employee aged mid thirty.

In summary it can be concluded that a new management approach results in different feedback depending on the background of the person asked. The first results suggest that there is no one size fits all concepts for leading people. The next section will apply the new idea of Agile project management to a project and effects on motivational patterns will be assessed in more detail.

Table 1:
*Feedback from Line-Scrum*

| Attitude | Numerical Rating |
|---|---|
| Positive | 50% |
| Neutral | 17% |
| Sceptical | 33% |

### 6.2 Project-Scrum - Agile Engineering

For a validation of the Agile Engineering approach, a prototype project has been conducted applying Scrum methodology for people and project management. The project was executed in the time frame from June to September 2014. The scope of the project can be described as a mixture between technical engineering on the one hand and organizational scope on the other hand. The project team was comprising of 7 engineers and can be characterized as cross-functional and diverse.

As the project scope was rather complex, breaking down the project into a clear sequential order and defining work packages following the waterfall method would have become a very complex task and consumed noticeable resources. Hence, following the Agile Engineering concept, an incremental approach delivering one piece after another building the big picture was selected and judged much more efficient. This requires a common understanding of the project scope and shared understanding of the big picture within the project team. Both are going to be realized by applying the Scrum approach enabling regular communication and information sharing. Communication will be realized in daily or bi-daily Scrum meetings.

Project execution was subdivided into three sprints each one running over a time period of approximately three weeks. As the project staff were not assigned fulltime to the project, a lean project management style was required giving maximum freedom and flexibility to the project team and preventing unnecessary overhead and delay due to interfaces not well organized. Allowing the team to self-organize is supposed to maximize outcomes for the given resources available.

The execution of the project has been handled with maximum involvement of the team members. After receiving the product backlog from higher management defining main deliverables of the project, the detail structure and scope was iterated with the team members.

These were part of creating the big picture, performing project planning for the different sprints and developing a logical structure of the project scope allowing each individual to select his pieces of contribution.

Verification of the Agile Engineering project has been done applying the Moving Motivator assessment. See section 4, as described by Juergen Appelo, (Appelo, 2012). The first step was to identify motivational patterns of the development team members as well as rating the effects of the new management concept. This process has been performed as follows:

1. The Moving Motivator cards needed to be ordered from least important (to the left) to most important (to the right) by each and every team member.
2. Effects of applying the new Agile Engineering approach contrasting the classic management style, were indicated by moving-up cards (positive effect) or shifting them down (negative effect). Keeping a card in its initial position meant that the motivational pattern assessed is not affected by the new management concept.
3. To identify motivational patterns of the individual team members the chosen order of importance of the ten motivational cards has been rated. The item on the left (least important) received a rating of 1, whereas the card on the right (most important) has been rated with 10. The determined results are shown in Table 2.

Assessing the highest mean value results of the ranking of driving motivators for the complete development team, Table 2, it can be found that key elements are curiosity and mastery as expected from an engineering division but also power is rated high. In a second row the motivators' freedom and status can be found. Although these values score lower regarding the mean value of the result, there was at least one employee scoring these criteria with a rating of ten. Hence, these motivators need to be considered relevant as well. Least important, order and relatedness have been rated, whereas, the relevance of order relative to the other ones is noticeable lower. Nevertheless, there was at least one rating of order with a number of eight indicating that this motivator cannot be ignored.

In summary, the assessment of the motivational patterns indicates that no motivator can be defined as less relevant as there were high ratings (maximum values) given to all of them. This result is kind of expected as the answers were collected from a diverse team and motivational patterns are strongly depending on the personal values of the person asked.

Table 2:
*Assessment of motivational patterns for the development team*

| | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Curiosity | 7,50 | 3,27 | 1 | 10 |
| Mastery | 7,17 | 3,66 | 2 | 10 |
| Power | 7,17 | 1,17 | 6 | 9 |
| Freedom | 6,67 | 2,80 | 2 | 10 |
| Status | 5,83 | 3,76 | 1 | 10 |
| Acceptance | 4,83 | 2,14 | 2 | 8 |
| Goal | 4,67 | 1,97 | 2 | 8 |
| Honour | 4,50 | 1,52 | 3 | 7 |
| Relatedness | 4,33 | 1,86 | 2 | 7 |
| Order | 2,33 | 2,80 | 1 | 8 |

Table 3:
*Assessment of Moving Motivators - Final Assessment*

| | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| Relatedness | 3,33 | 2,58 | 0 | 5 |
| Curiosity | 2,50 | 4,18 | -5 | 5 |
| Mastery | 1,67 | 4,08 | -5 | 5 |
| Acceptance | 1,67 | 2,58 | 0 | 5 |
| Freedom | 1,67 | 4,08 | -5 | 5 |
| Order | 1,67 | 2,58 | 0 | 5 |
| Power | 0,83 | 3,76 | -5 | 5 |
| Honour | 0,83 | 2,04 | 0 | 5 |
| Goal | 0,83 | 4,92 | -5 | 5 |
| Status | 0,00 | 3,16 | -5 | 5 |

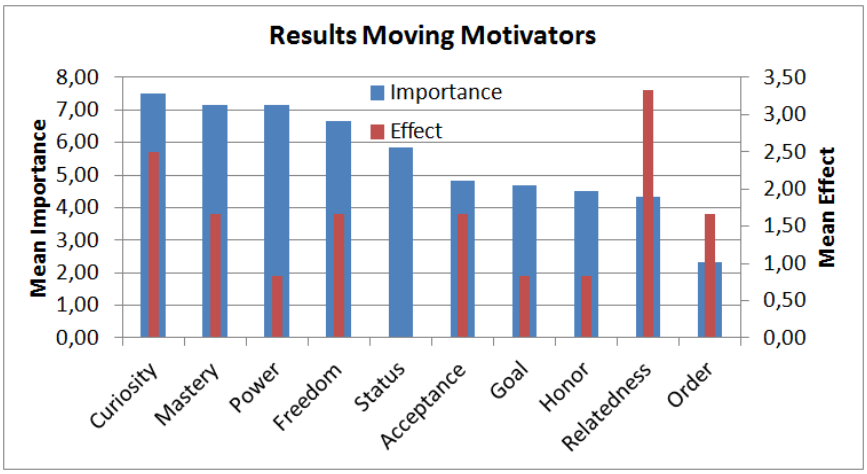


Figure 3: Overview on most important motivators and rated effect

The assessment of motivational effects has been done by means of a fully anonymous collection of feedback. For this purpose, the Moving Motivator cards, as introduced in section 3, have been applied in a different manner. Everybody rated the motivators by himself following the effect determined, whether it is positively, neutral or negative. Finally, the cards of all team members were collected in three different boxes representing the same three categories of motivation.

The reason for applying this anonymous data collection was to get the real picture of motivation, which was not affected by any group dynamics. By ordering the cards and putting them into a box, each team member could feel safe, e.g. in case he wanted to highlight a negative trend in motivation. This more stringent approach, of rating the new concept, has been chosen to challenge the new management concept proving that the measured increase in motivation is real. The drawback of this method is that the result cannot be linked with individual team members. One measure to allow this would have been to mark each set of Moving Motivator cards. However, it has been decided not to do this to make people feel safe regarding their votes.

In the following, the resulting level of motivation of each motivator is assessed individually. Numerical values have been assigned to each vote. A positive trend

received +5 points, a negative result -5 and a neutral rating 0 points. The overall rating is summarized in Table 3. On the clearly positive side considering strongly positive mean values of the survey, the intrinsic motivators' relatedness, curiosity, acceptance, order, freedom and mastery can be found. More balanced results are obtained for honour, power, goal and status.

Assessing the results in more detail it can be obtained that all motivators received at least one positive rating as indicated by the maximum rating of 5. Additionally, categories can be identified being characterized by a minimum value of 0, which means that there was no negative effect of the new management approach measured. These motivators are Honour, Acceptance and Order. For the remaining categories also negative feedback has been recorder as indicated by the lowest rating of -5. As the survey has been performed fully anonymously it cannot be tracked if all the negative feedback was given by one or several persons. Hence, it cannot be excluded that for certain reasons one person has been particularly demotivated by elements of the new management concept or by the leadership style of the person in charge.

The results have also been graphically represented relative to the determined importance of each Moving Motivator (importance rating has been taken over from the assessment above), Figure 3.

## 7 Conclusions

Summarizing all the findings, it can be observed that for most of motivational patterns an increase has been rated by the participants of the case study. Examples to be mentioned here are a strong increase in curiosity as an intrinsic motivator beneficially affecting creative solutions to complicated problems. Another motivator noticeably positively rated is relatedness, which means positive effects for team building and questions of group dynamics. On the other hand it is worth mentioning a balanced towards goal orientation, which might be explained by the incremental approach, meaning, that the final goal of the efforts is not always visible.

The reason behind the divers' results can be explained by the different personalities forming a team. Each and every employee is an individual with different interests and motivational patterns. As a result, there is no one-size-fits-all approach for a management style motivating all employees to the same level. The same holds for the manager in charge of the team. Also this person might cause different reactions of the team members on a chosen management style, as personal interaction is a big driver of motivation as well.

Regarding the methodology, which is referred to as being equal to Agile Project Management, Agile Software development and Scrum, it can be discussed whether Agile Engineering is following the pure theory and ideas as they have been described, e.g. by Ken Schwaber. However, it should be clear that managers, and the philosophy of managing people, will have to be adapted to meet the needs of the new generation of employees joining companies in those days. Agile Engineering might contribute here shaping the business environment of the future.

For further research, it is recommended to test the developed Agile Engineering concept with a different setup of teams compared to the one described in this paper. The idea here is to see how different people forming the project team react on the new idea of managing projects in an Agile way. It can be assumed that more prototype projects will also highlight further areas where adaptations of the new concept might be necessary.

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