Effects of Automated Competency Evaluation on Software Engineers' Emotions and Motivation: A Case Study

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ABSTRACT

Software development consulting companies must be able to select the best suited developers for their clients. A method of doing this is through competence evaluation. Sigma IT Consulting uses manual methods consisting of heavy documentation for employees to fill in their competence. Problems such as data inconsistencies in documentation of competency might cause difficulties for managers while making decisions to assign right developer to the right job. Such difficulties may lead to frustration in managers and negatively affect their decision-making process. Similarly, developers might feel themselves under pressure always having to fill in the competency documents whenever the manager makes requests among all the tasks the developers are busy with and feeling under pressure might have negative effects on developers' performance. Researchers have shown that negative emotions lead to poor software development performance, while positive emotions improve developers' performance. Competency evaluation is an integral part of the daily routine at Sigma IT Consulting. Therefore, negative effects of competency sheets on developers and managers cannot be tolerated. In this case study, having investigated how competency is evaluated at Sigma IT and what employees think about competency evaluation in general, we implemented a web-based competency evaluation platform. When supplemented with qualitative data, the results of the Self-Assessment Manikin (SAM) and Intrinsic Motivation Inventory (IMI) we conducted show that automation of competency evaluation as a web-based platform has positive effects on developers' and managers' emotions and motivations. Interviews we conducted with developers and managers also include their positive thoughts about automation of the competency evaluation.

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CCS CONCEPTS

• Software and its Engineering → Software Creation and Management; • Collaboration in software development → Programming Teams;

KEYWORDS

Competency Evaluation, Emotions. Motivation

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1 INTRODUCTION

Software development consulting companies work on developing software in a large variety of programming languages, therefore it is of utmost importance to identify which developers to choose for a team that will best serve their client. To address this problem, companies such as Sigma IT Consulting came up with competence evaluation methods that can be used to rank the employees based on programming knowledge and soft skills consisting of personal attributes that enable someone to interact effectively and harmoniously with other people [17].

The current competency evaluation at Sigma IT Consulting is quite manual consisting of heavy documentation. Excel Sheets are used to keep track of the employees' knowledge in software engineering that is filled in manually by the employees and evaluated manually by the project managers. Among the disadvantages of manual competency evaluation are data inconsistencies, which might cause difficulties for project managers while making decisions to assign right developer to the right job. Such difficulties may lead to frustration in managers and negatively affect their decision-making process. Similarly, developers might feel themselves under pressure always having to fill in the competency documents whenever the manager makes requests due to their tight schedules and feeling under pressure might have negative effects on developers' performance.

To address these issues, we developed a web based competency evaluation platform whose system architecture and user interface screen shots can be found in GitHub (https://github.com/Competency Study/CompetencyStudy). Having presented our implementation to the employees of Sigma IT, we conducted user studies with 9 subjects consisting of 7 developers and 2 managers. The goal of these user studies was to investigate the effects of the automation of the competency evaluation on software engineers' emotions and motivation.

Motivations of software developers has long been studied [1, 15]. Research in cognitive science shows that there is a relationship between emotions and motivation. According to Franklin and Ramamurthy [7] "Motivations prime actions, values serve to choose between motivations, emotions provide a common currency for values, and emotions implement motivations." Emotions affect the decision making of the project managers and also the performance of developers. In the literature, there is empirical evidence that positive emotions such as happiness cause increase in developer performance [9], while negative emotions such as frustration have negative effects on performance [13].

Therefore, this case study aims to answer the following research question:

RQ: How does partial automation of the competence evaluation platform affect emotions and motivations of software engineer (i.e., software developers and project managers)?

The rest of the paper is organised as follows: Section 2 gives information about Sigma IT, which is the company where the case study took place as well as mentioning related work. Section 3. Results are given and discussed in section 4. Threats to validity are addressed in section 5 and finally section 6 concludes and mentions future work.

2 BACKGROUND AND RELATED WORK

2.1 Case Company Description

The company involved in this case study is Sigma IT Consulting Company, which is an an international consultant company in software engineering sector and its headquarters is in Gothenburg, Sweden. The company has the highest number of branches in Sweden among the Swedish IT consulting companies and they are active in 20 locations in Sweden. The company is also expanding internationally, and it has in total 200 employees who are specialized in software development and/or project management. Sigma IT Consulting offers their employees training services in order to increase their knowledge and skills in various programming languages.

2.2 Related Work

There are many studies in the literature regarding competency evaluation. Hamel and Prahalad define core competence as the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technology [11]. Some studies state that the competence of the employees does not consist of purely stating your technical skills, but also the ability to solve abstract problems. According to Bergersen and Gustafsson, when employees are faced with a programming problem they cannot rely solely on their knowledge of the programming language, but they must also rely on their ability solve abstract problems [2].

There are different ways to measure competency. When trying to measure programming skills a study suggests an extensive questionnaire where employees fill in their year, level estimation, years of experiences and the size of projects [6]. This questionnaire focuses on evaluating the developer programming skills as a whole, but used only Java, C, Haskel and Prolog as a base for the rating rather than ask them about specific programming languages to understand their level of experience per programming languages [6]. An extension of this paper uses a similar approach with the addition of some questions that explore how they compare their experience with people that have been in the field over 20 years [16].

Cognitive aspects such as emotions, stress also have their place when performing competence evaluation when it comes to team building and management within software engineering. As addressed by Chilton et al., ability to manage stress and strain to ensure productivity could be seen as a competence soft skill that is highly valuable to have in addition to the technical competence required for the position [16]. On the other hand, Graziotin et al. provide empirical evidence that positive emotions such as happiness cause increase in developer performance [8, 9], study by Muller and Fritz is motivated by the fact that negative emotions such as frustration have negative effects on performance of software developers [13].

3 RESEARCH METHODOLOGY

This research study was conducted as a case study in order to investigate how automation of competency evaluation affects software engineers' emotions and motivation in Sigma IT, which is a Swedish consulting company specialised in software development. We collected qualitative data through interviews and conducted user studies with 9 employees of the company which resulted in collection of both qualitative and quantitative data.

During the user studies, we conducted a Self Assessment Manikin (SAM) [5] by referring to the guidelines for psycho-empirical software engineering by Graziotin et al. [10] and an Intrinsic Motivation Inventory (IMI) [14] to collect quantitative data about the participant's emotions and motivations. This quantitative data was complemented by qualitative data obtained from think aloud protocols that were applied during the user study, by making the participants explain their reasoning behind the statements they selected and the decisions they made.

Before the user study with each participant, we presented the demo to the the participant. The demo session included the functionalities and features of the web-based competency platform prototype and showed how it can be used.

The user study consists of the following phases:

- (1) Explain the task with the competency sheet to the participant and let the participant perform the task. Ask the participant to think aloud while performing the task.
- (2) Conduct SAM.
- (3) Conduct IMI.
- (4) Explain the task with the web-based competency platform and let the participant perform the task. Ask the participant to think aloud while performing the task.
- (5) Conduct SAM.

- (6) Conduct IMI.
- (7) Conduct a small interview with follow-up questions.

Out of 9 participants, randomly 3 participants were randomly selected and the order of the phases 1) and 4) were swapped for those participants. The aim of such swapping is to reduce mere exposure effect that affects how a person views something that they are not familiar with [4]. The further details of the user study protocol can be found in GitHub (https://github.com/CompetencyStudy/CompetencyStudy). Below we explain the main components of the user study, which are "Demo and Tasks", SAM and IMI, respectively.

3.1 Demo and Tasks

As mentioned previously, developers and project managers use competency sheets in different ways to perform different tasks. While developers use the sheet to monitor the development of their skills and knowledge as well as reflecting their current skills to be selected by managers for software projects that suit them most, managers use the sheets for the selection of the right developer for a given project. Therefore the demo session for the web-based competency platform prototype as well as the tasks with the competency sheet were conducted differently depending on the role of the participant (i.e., project manager or developer.).

While conducting the task with the developers, the researchers asked the developers to mimic the process of updating their competence as they would do if their manager asked them. The main goal in doing this was to ensure a realistic setting while conducting the task. For this purpose, while conducting the task with competence sheets, the developers were provided an email client where they would download a copy of the competence sheet. Developers were then asked to update their competence for five areas of programming and soft skills. These fields were randomly selected by the researchers. Once the developers filled in the sheet, they were asked to send it as an attachment via email by replying the initial sender of the sheet. During the task with the web-based platform, the researchers asked the developers only to fill in five fields of programming and soft skill that were randomly selected by the researchers.

Regarding the tasks for managers, the researchers asked the manager to mimic the process of creating a new profile and adding five random programming and soft skills to that profile. The manager was then asked to search for developers who matched the created profile. The managers were asked to perform this task both with the competency sheet and the web-based platform.

The participants used the think aloud technique [3] when performing the tasks in order to give the researchers an opportunity to know what they were thinking about as well as allowing them to be corrected by the researchers if there is something that they might have misunderstood. This also allowed for the researchers to understand the reasoning behind participants' choices when performing the emotions and motivation assessments.

3.2 Self Assessment Manikin (SAM)

SAM is a non-verbal assessment, which aims to measure three key emotions that a person could feel as a reaction to using an object [12]. These three different kinds of feelings are as follows: Happy vs. Unhappy, Excited vs. Calm, and Controlled vs. In-control. SAM

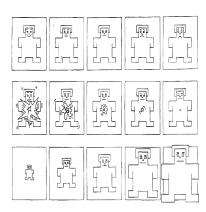


Figure 1: Self Assessment Manikin (SAM)

is shown in Figure 1. The first row that starts from a happy face and ends at a sad face represents valence. The second row represents the arousal of emotion, ranging sluggish, dull, unaroused. The third row represents dominance, by starting from a small figure representing "being controlled" to a large and dominant figure representing "being in-control". By conducting SAM after the task with the competence sheet and after the task with the web-based competence platform, we aim to find out how developers' and managers' emotions are affected by partial automation of competency evaluation. While conducting SAM to the participants (i.e., developers and managers), the researchers used a protocol consisting of a text including what the researchers should say to the participants in order to minimize their influence on the participant and treat each participant similarly in order to circumvent negative effects of threats to internal validity. The SAM protocol containing the text has been adapted from the technical manual of Internal Affective Picture System (IAPS) [36] and it can be found in GitHub (https://github.com/CompetencyStudy/CompetencyStudy). On SAM, which is shown in Figure 1, the participant can select any of the 5 figures comprising each scale and between any two figures. As it is shown in Figure 1, this results in a 9 point scale for each dimension.

3.3 Intrinsic Motivation Inventory (IMI)

IMI assesses the participant's "interest/enjoyment", "perceived competence", "effort", "value/usefulness", "felt pressure and tension", and "perceived choice", while performing a given activity, thus yielding six subscale scores [31]. Each subscale consists of 5-7 items (statements) and each item can be rated on a scale from 1-7, 1, 4 and 7 corresponding to "not at all true", "somewhat true" and "very true", respectively. We conducted IMI to managers and developers after the task with competence sheet and also after the task with web-based competency platform. We combined the results we obtained with the SAM results and qualitative data obtained from the think aloud protocols in order to answer our research questions.

While preparing our IMI survey, we selected the following subscale items that were relevant to our user study from the whole inventory: "Interest/Enjoyment", "Perceived Competence", "Pressure/Tension" and "Value/Usefulness". The IMI statements can be

found inside the user study protocol in GitHub (https:/github.com/CompetencyStudy/CompetencyStudy).

3.4 Follow-up Questions

The user studies were followed by some interview questions to investigate participants' thoughts about the automation of the competency sheet into a web-based platform and their impressions about the web-based platform that was developed by researchers. The interview questions can be found inside the user study protocol in GitHub (https://github.com/CompetencyStudy/CompetencyStudy).

4 RESULTS

The data collection consisted of three parts. The first part contained the results of the emotions of the participants that were collected with SAM. The second part contained the results of the motivation of the participants that were collected with the IMI assessment. The third part was a short interview, which aimed to obtain information about what managers and developers think about the web-based competency platform. Each developer was given an ID that starts with "user" and then a number. The same was done for the manager except that the ID starts with "manager" followed by a number. In our analysis, we also added data we obtained from user10, who was the participant of our pilot user studies, since no modifications were made to the content of the study after the pilot.

4.1 SAM Results

Table 1 displays the SAM results for each of the 9 participants, while the average values are given in Table 2. The first column of Table 1 shows how using manual and automated competency evaluation made them happy/unhappy. In the range 1-9, a value of 5 represents feeling indifferent. If the value is higher than 5 then the participant feels unhappy. On the other hand, if the value is less than 5 then the participant is happy. As it can be seen, from Table 1 and Table 2, using the automated competency evaluation platform made the participants happier. In Table 2, the average value for happiness/unhappiness while using the website is 2.5, the average for value while using the sheet is 4.9. This shows that the general effect of the web-platform on the emotions is increased happiness.

The third column of Table 1 displays the results of how using the manual and automated competency evaluation solutions made the developers and managers excited/calm. The higher the number the more calm the participant, and hence 9 is very calm. The lower the number the more excited the participant, 1 is very excited. Table 1 shows lower values when using the web platform, thus showing that the developers and managers are more excited when using automated competency evaluation platform. As shown in Table 2 the average value for excitement calmness while using the website is 4.4, the average for value while using the sheet is 6.4, which shows that on average the developers and managers are more excited when using the website. During the user studies, one of the participants commented as follows:

"I am excited by how easy it is to update my competence in comparison to the sheet." The fourth column of Table 1 displays the results of how using the web platform/sheet made them feel controlled/in-control. The higher the number the more in-control the participant is, hence, 9 implies being in-control. The lower the number the more controlled the participant, 1 is controlled.

As it can be seen in the fifth column of Table 1, developers and managers feel more in-control when using the site. In Table 2, the average value for controlled/in-control while using the web based competency platform is 6.5, the average for value while using the sheet is 5.2, which shows that on average the developers and managers feel slightly more in control when using the web platform. Regarding feeling in-control when using the web-based competency platform, one of the participants commented as follows:

"The ability to update my sheet in real-time makes me feel like I am more in-control over my competence and I can update it whenever I want."

4.2 IMI Results

As mentioned previously, for this study we selected four subscales, which were "Interest/Enjoyment", "Perceived Competence", "Pressure/Tension' and "Value/Usefulness", respectively. For each subscale 4 to 9 items (statements) were selected. The results for each subscale were calculated by taking the average of the scores in the range 1-7 the participants assigned to the items.

The "Interest/Enjoyment" subscale measures the extent to which the performed tasks were interesting and enjoyable. The values range from 1 to 7 a higher value when using the web platform is more desirable for the this subscale, since it shows that the web platform has a positive effect on the motivation of the developers/managers. Table 3 shows higher values when using the web platform, thus showing that the developers and the managers feel more enjoyment/interest when using the site. As shown in Table 4, the average value for enjoyment/interest while using the website is 5.8, the average for value while using the sheet is 3.5. These values are in line with the following comments by one of the participants:

"I like that I can learn more in the areas that I am not familiar with, this gives more reasons to go back and update my sheet."

The second subscale that was examined was the perceived competence, which evaluates how the developers'/managers' perceived ability to perform the given task by judging their skill. The values range from 1 to 7, a higher value when using the web platform is more desirable for this subscale, since it shows that the web platform is easier to use. Table 3 shows higher values when using the web platform, thus showing that the developers and the managers feel more competent when using the site. As shown in Table 4, the average value for competent while using the website is 6.2, the average for value while using the sheet is 5.1, which web platform on average the developers and managers are more competent when using the website.

"I think that filling in a sheet is easy, so there is no difference between the website and the sheet in that area. But I think that the

	Нарру у	s. Unhappy	Calm	vs. Excited	Controlled vs. In control		
User ID	Manual	Automated	Manual	Automated	Manual	Automated	
user1	5	5 4		3	4	7	
user2	8	4	8	6	5	8	
user3	7	3	7	5	3	6	
user4	4	2	6	1	3	2	
user5	5	3	7	4	4	8	
user6	4	3	7	8	9	8	
user10 (pilot)	5	1	6	3	7	8	
manager1	3	2	2	2	3	3	
manager2	3	1	8	8	9	9	

Table 1: SAM Results for Manual vs. Automated Competency Evaluations

Table 2: SAM Results as Average Values for Manual and Automated Competency Evaluations

Feeling	Manual	Automated		
Happy vs. unhappy	4.9	2.5		
Calm vs. excited	6.4	4.4		
Controlled vs. in-control	5.2	6.5		

website is more convenient since I don't need to search for an email and I don't need to remember the file location."

The third subscale that was examined was the effort/importance, which evaluates how much effort the developers/managers spent on the task and their perceived importance of the task. The values range from 1 to 7, a higher value being more desirable. The values obtained from the sheet and web platform should be similar seeing as the main goal of the web platform should be the same as the sheet. Table 3 shows higher values when using the web platform, thus showing that the developers and the managers put more effort into and feel that the task is more important when using the site. As shown in Table 4, the average value for competence while using the website is 4.7, the average for value while using the sheet is 4.6, which shows that on average the developers and managers put slightly more effort and view the task as slightly more important when using the website.

"Filling in my competence is important so it doesn't matter if I do it online or on the sheet. I spend the same effort thinking about the values of my competence, but I think that sending the sheet as an email attachment makes the sheet takes a little bit more effort."

The fourth subscale that was examined was the pressure/tension. This subscale evaluates how the developers/managers viewed the pressure and tension inflicted from doing the task. The values range from zero to seven, a lower value when using the web platform is more desirable for the this subscale, since it shows that the web platform is not stressful to use. Table 3 shows lower values when using the web platform, thus showing that the developers and the managers feel less anxious when using the site. The average value for competency, while using the website is 2.7, the average for value while using the sheet is 2.9, as shown in Table 4. This shows that

on average the developers and managers feel slightly less anxious when using the website.

"There is always external stress from other projects and deadlines that makes me feel anxious when filling in the sheet."

The fifth subscale that was examined was the value/usefulness. This subscale evaluates how the developers/managers viewed the usefulness of the task the task. The values range from 1 to 7, a higher value when using the web platform is more desirable for this subscale, since it shows that the web platform is useful. Table 3 shows higher values when using the web platform, thus showing that the developers and the managers view the website as more useful/valuable tool when doing their tasks. Table 4 shows the average values, which are 6.8 and 5.4 for using the website and for using the sheet, respectively. This shows that on average the developers and managers view the website as more useful/valuable.

"I like how I don't need to email my manager when I update my competence, I can go to the website when I want and I update it and I can also learn more about a programming language if I want."

4.3 Interview Results

There were three main areas that were examined in this part by asking two questions to all the developers/managers and one additional question to the ones that helped create the sheet. The entire transcript for the interviews can be found in GitHub (https://github.com/CompetencyStudy/CompetencyStudy).

- (1) Does the web based system perform as expected in practice?
- (2) What do you think about keeping track of and updating the web-based competence system?
- (3) What are your thoughts about turning the competence sheet into a web-based system?

The first question was directed towards the employees that helped create the sheet, the responses that were obtained from this question state that the web-based system does indeed perform as expected: "Yes I think so. However, it has some potential for improvement."

The second question was directed towards both the developers and the managers. The aim of the question was to examine how effectively the web platform can help the developers keep track of

	Interest	/enjoyment	Perceived competence Effort/importance		Pressure/tension		Value/usefulness			
User ID	Manual	Automated	Manual	Automated	Manual	Automated	Manual	Automated	Manual	Automated
user1	4	5.5	4	5.5	3.25	4.5	3.6	3	4.6	5.6
user2	1.75	5.5	4	6.5	4	5	3	3	4.2	6
user3	2.5	5.25	6	6	3.5	4.5	2.8	2.4	5.8	6.2
user4	4	7	5.5	7	6	5.75	3.6	4.2	6.8	7
user5	3.5	5.75	5.5	6	5	5.25	2	1.4	4.4	5.6
user6	2.25	4	7	6.5	3.75	3.75	2	2.2	5	5.4
user10 (pilot)	2	6.5	4.5	5.5	3.5	4.25	4.4	3.4	4.8	6.2
manager1	6.75	6.25	6	6	5.5	4.25	2.4	2.2	6.6	6.8
manager2	5	6.75	4	7	6.5	4.75	2.2	2.2	6.4	7

Table 3: IMI Results for Manual Competency Evaluations

Table 4: IMI Results as Average Values for Manual and Automated Competency Evaluations. Values range from 1-7. Higher is better for all subscales except for "Pressure/Tension".

IMI subscale	Manual	Automated		
Interest/enjoyment	3.5	5.8		
Perceived competence	5.2	6.2		
Effort/importance	4.6	4.7		
Pressure/tension	2.9	2.7		
Value/usefulness	5.4	6.2		

and update their competence.

"I think it was good. Better and easier than before. More accessible in comparison to the sheet."

The third question was also directed towards both the developers and the managers. The question aims at validating the decision of creating a web platform. All the employees that were interviewed thought that the decision to make the web platform was good and it's overall a more pleasant and effective experience to update competence and keep track of it.: "It's a good and solid way to go. The 'profile' and 'learn more' functionalities make it awesome. There are no limitations to this so more functionality can easily be added."

It is also important to note that the managers argue that the excel sheet is an excellent tool in the short-run. However, they do believe that the web platform should be the way to go since it supports an expanding company with changing needs.

5 THREATS TO VALIDITY

In order to address mere exposure effect, half of the interviewers were shown the sheet first and the second half were shown the web platform first. Another internal validity is the low sample size of employees available for the study, due to the limited free time that the developers and managers had, data could only be collected from 9 people over the span of two days on two separate occasions for phase one and three. By having a larger number of employees to participate in the study to provide a more extensive

data set would assist in identifying further potential answers to our research questions. However, in order to circumvent the problem of small number of participants, we complemented the quantitative data we obtained from SAM and IMI results with qualitative data obtained from interviews and think aloud sessions.

The main external threat to validity was our study being for a specific software within a specific scope. Due to designing something that would only be used inside Sigma IT Consulting and not using it to study the effects in other companies. This was a known external threat to validity from the beginning, since the prototype is based on the competence sheet that was already in use at Sigma IT Consulting. In order to overcome this threat to validity, as future work we aim to conduct more user studies with different teams within the other departments inside Sigma. While conducting the interviews and questionnaires having a realistic setting in order to ensure that the answers actually reflect what the interviewee would feel when conducting the tasks in reality. In order to ensure this the researchers simulated a setting where the interviewee would be asked to conduct the tasks in the same procedure with some limitations due to time constraints.

6 CONCLUSIONS AND FUTURE WORK

In this research, we automated the competence sheet into a web platform for Sigma IT, which is a Swedish software development consulting company. After the implementation, in order to explore the effects of automation of competency on software engineers' emotions and motivation, we designed and conducted user studies for the manual competence sheet and the new web-based competence platform. This helped us gather information about the motivation and emotions of the employees. The obtained results show that automation of competency evaluation in the form of a web platform has a positive impact on the emotions and motivation of the employees, and no disadvantages were identified.

As future work, we also aim to conduct the user studies to to more project managers and developers within Sigma IT in order to increase the statistical validity of SAM and IMI results. We'll also longitudinal studies in order to see long time effects of the web-based competency evaluation platform on managers' and developers' emotions and motivation.

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