Measuring Success in Agile Software Development Projects: a GQM Approach

Abdullah Aldahmash
Electronics and Computer Science
University of Southampton
Southampton, UK
e-mail: a.aldahmash@soton.ac.uk

Andy Gravell
Electronics and Computer Science
University of Southampton
Southampton, UK
e-mail: amg@ecs.soton.ac.uk

***Abstract*— Agile software development has become one of the most commonly used methodologies for developing software. It promises to deliver many benefits, but nevertheless, the implementation of agile practices and techniques require many changes that might be a challenge for organizations attempting to succeed with agile software development projects. Claiming the success of agile software projects is difficult, and there is a need for more measurements with which agile success could be evaluated. This paper develops an instrument with which the success of an agile software development project could be measured. The criteria of the success are driven from the Critical Success Factors (CSFs) of agile development which have been identified prior developing this instrument. The proposed instrument will evaluate the success of agile software development projects in achieving these identified success factors. The instrument was developed following the Goal Question Metric (GQM) approach. This study conducted semi-structured interviews with 13 experts in the field of agile development. The aim of these interviews was to review and confirm the proposed instrument for measuring the success of agile projects. Following comments from the interviews, the instrument was revised. The developed instrument proposes measuring the agile success using 6 goals, 30 questions, and 7 metrics.**

Keywords—Agile; Agile success; GQM; Software metrics; Agile project

I. INTRODUCTION

Agile practices and techniques have been adopted by many organizations. These organizations face many challenges during the agile transformation. These challenges are related to a variety of aspects, such as people, culture, and technology. During a previous study [1] we identified the critical success factors of agile software development. Having identified the success factors of agile software development, now we will focus on studying how the success could be measured; claiming the success of agile software development is problematic. Therefore, there should be more metrics and systematic measurements that could evaluate the success of agile software development projects. There is also a need for more measurements with which the adoption of agile practices and techniques could be assessed.

The nature of agile software development requires new metrics that address the agility. One study [2] concluded that not all the software traditional lifecycle metrics are suitable for agile software development. It was suggested that future work should focus on how the use of the traditional software measurement could be adapted to work with agile development or to develop new metrics for agile development. Recent research [3] reviewed a total of 22 software metrics and resulted with only 10 metrics that could be used in agile software development. Therefore, there is a need for more software metrics that could be used to measure the status of agile software development.

This study selected the GQM approach to develop an instrument for measuring the success of agile software development. This selection was based on a suggestion from [4] findings, which revealed that the GQM approach is more relevant to the nature of agile software projects with short-cyclic iterations. GQM will provide measurements with clear purposes and goals and will result in saving the time of developing the measurement which is one of the agile development objectives. In this paper, an instrument is developed using the GQM approach. This instrument aimed to measure the success of agile software development projects.

This paper is organized as follows: Section I is an introduction. Following which, Section II is a background where the literature review is discussed. In Section III, the related work is presented. Section IV discusses the research methodology used in this study is presented. Section V is pertaining to the development of the proposed instrument. Following that, Section VI discusses the review of the instrument. Lastly, Section VII concludes the paper and puts forth the future work.

II. BACKGROUND

In this section, the relevant literature was reviewed. Section A reviews the literature of the agile software development. Section B discusses the introduction of the GQM approach and how it could be employed.

A. Agile Software Development

In 2001, a group of software engineers established the agile manifesto [5] during which, they introduced four values and twelve principles of agile software development. Since then, agile practices and techniques have evolved. According to Agile Alliance network, agile software development defined as “an umbrella term for a set of methods and practices based on the values and principles expressed in the Agile Manifesto. Solutions evolve through collaboration between self-organizing, cross-functional teams utilizing the appropriate practices for their context” [6].

The main characteristics that the agile development include: communication and collaboration, support innovation/creativity, embrace changes, and the development should be iterative and indivisible [7]. Agile development advocates frequent delivery of working software. This ensures

that feedback will be received early and so will be the changes in requirements. Agile development also embraces changes and conflicts during the development rather than rejecting them [8].

The latest State of Agile Survey 2018 [9] revealed that the top three reasons which drive the organizations to adopt agile were to accelerate product delivery, to manage changing requirements, and to increase productivity. According to a survey from Microsoft research, the top three paybacks from agile development are: improve the communication, enhance the delivery, and better respond to the changes. Conversely, the three top difficulties with agile development are: large-scale projects, number of required meetings, and rigorous management culture [10].

B. Goal-Question-Metric Approach

The instrument will be developed by using the GQM approach. GQM was proposed by Basili and Weiss [11] with the aim of introducing a systematic way of defining goals that could easily be refined into questions and linked to metrics. The GQM approach has three levels: conceptual level (Goal), operational level (Question), and quantitative level (Metric).

The goals are usually defined for specific purposes from a certain perspective and for a given object. Therefore, the usage of GQM will help in ensuring that the defined measurements will be defined with the aim of achieving specific goals [12]. The questions are used to describe the approach to achieving the goals and how it is going to be achieved. The metrics are set of data linked to each question aiming to answer it and it could be objective or subjective. Defining goals is beneficial to focus on the important aspects. Writing questions will make the goals more specific and will suggest the relevant metrics [13]. An example of the structure of GQM is illustrated in Figure 1.

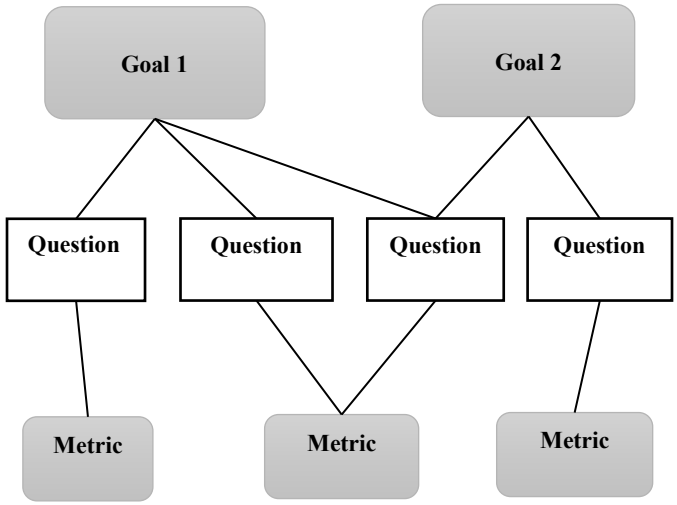

Figure 1. An Example of GQM Structure.

Using GQM approach to develop software measurements is associated with many benefits. Some of these benefits are improving the software product quality, enhancing software processes, and increasing the team cooperation [14]. The GQM-based measurement approach will help in avoiding irrelevant measurements through the regular feedback and by involving the project team to define measurements that are linked to the agreed upon goals [15]. GQM is a systematic approach of representing and combining a set of high-level goals into measurements. The result of implementing GQM is the specification of a set of metrics addressing a particular set of goals and rules for interpreting these results [16]. It is hoped that by implementing the GQM approach it will be possible to define a list of metrics which could measure the success of an agile software development project in an organization.

III. RELATED WORK

A great deal of studies has investigated the status of measurements in agile software development. According to Javdani et. al [17], measurements in agile software development are unlike the measurements in traditional software development. It was suggested that there is a need for more agile measurements especially in the following areas: productivity and velocity, and the changing requirements in agile. Furthermore, Ayed et. al [18] introduced a measurement-based framework for measuring the adoption and customization of agile methods. A set of metrics have been introduced and categorised into three categories: organisation level metrics, product level metrics, and process level metrics. However, the introduced metrics were not introduced in a practical way which the organizations are looking for. Agile measurements need to be confirmed and validated through empirical methodologies in order to gain an acceptance from the agile practitioners. This paper is planning to validate the proposed instrument by conducting experts' interviews. Heidenberg et. al [19] introduced a metrics model following GQM to measure the impact of agile transformation in software development organizations. Their model focused on measuring the business value, lead-time, and efficiency of the agile software development transformation. It was indicated that more measurements are necessary to assess the agile software development status in organizations attempting for agile transformation.

A recent study [20] has also attempted to provide a quantitative measurement of the impact of agile transformation in software development organizations. They proposed a model with quantitative metrics following the GQM approach. The proposed model consists of one goal, four questions, and eight metrics following the structure of the GQM approach. While they introduced quantitative metrics, they indicated that qualitative metrics are needed as well. It was suggested that future work might concentrate on providing qualitative metrics with which the status of agile software development could be evaluated and measured.

Fontana et. al [21] conducted a systematic review on the agile development maturity models and they compared these models aiming to develop a model which could evaluate the adoption of agile practices and techniques in an organisation. They found and reviewed fourteen models which assess the agile maturity, of which six models were introduced in the last four years. Most of these available models are built on a combination between agile principles and Capability Maturity Model Integration (CMMI). Fontana et. al [21] recommended that future works should focus on empirical validation of these

measurements which this research already achieved. While our instrument focused on measuring the success of implementing each success factor, these models were designed to measure the maturity of each agile practice independently. Both ways could be used to indicate the success in implementing agile software development projects.

Chita [22] suggested that the activity theory, which is usually used in social science, could be used to assess the factors for successful agile software development implementation, since the agile success is built on organisational, cultural, and social factors. They developed a model following the activity theory for successful agile adoption and they indicated that their on-going research will validate this model by conducting a case study.

Laanti [23] introduced a framework which could assess the agile transformation in large software development organisations. The framework classified the status of the organisations into five categories from beginner organisations to world-class organisations. While the framework assesses the agile adoption in the organisations, it lacks details on how organisations could evaluate their own adoption and how they could improve their agile transformation.

The findings obtained as a result of this paper and of the abovementioned emerging related work focused on understanding how the organizations could succeed in implementing agile practices. Furthermore, how the success in implementing agile practices could be measured and assessed. This shows the needs for more research that could work to validate these measurements and to introduce them to be used by agile software development practitioners.

In this paper, the proposed instrument used a mix of qualitative metrics and quantitative metrics to measure the success of agile software development projects. The proposed instrument will be reviewed by agile experts and it will be validated through conducting practical case studies.

IV. Research Methodology

The proposed instrument was developed using the GQM approach. This study followed a qualitative method which is semi-structured interviews with agile experts. These interviews were necessary to validate the proposed instrument. An invitation of participation was sent to a total of 28 experts. The criterion of selecting the experts which was used is that the expert should have at least 5 years of experience with agile software development. Out of the 28-reached experts, 13 experts were willing to participate in this research. These participants came from various countries, including the USA, Saudi Arabia, the UK, and France. The industries which the interview participants represent include, but are not limited to: Education sector, Finance and Banking sector, and Information Technology & Software sector. The interviewed experts represent different types of organizations which ranges from small organizations with only 15-30 employees to big multi-nation organizations. The participants were shown the instrument, following which they had the chance to ask for clarifications if needed. Then, they were asked about each item and to propose new items to the instrument. The interviews last, on average, approximately from 35 to 60 minutes.

V. Instrument Development

As identified in the literature, more measurements are needed for agile projects. The proposed instrument was developed for the purpose of measuring the success of agile software development projects. The GQM approach was selected to build the instrument considering its effeteness in detecting a systematic way of linking the metrics to the organizational goals and needs.

The first step of following the GQM approach is to identify the goal or the set of goals. The goal of this study was to measure the success of agile projects. Along with 6 sub goals selected as a result of a review of the success factors of agile software development [1], which identified the following factors as critical success factors of agile projects: Communication, Customer Involvement, Team Capability and Training, Top management Support, Organizational Culture, Delivery Strategy, Agile Software Development Practices and Techniques, and Project Management (PM) Process [1].

As suggested by GQM, the eight identified CSFs will be rewritten to be a set of goals. The two success factors of agile practices and techniques, and project management approach merged into one goal. This is because these two factors are about a selection process of available agile techniques and PM approaches; also, this was done to avoid the replication of having two goals about a selection process. Thus, the goal will be to have an appropriate selection of these available agile practices and techniques and PM approaches.

The organization culture is a soft factor which is hard to be measured and it contains many aspects which overlap with other success factors such as communication and top management support factors as per [24]. Thus, in the developed instrument, the organizational culture factor will not be an independent goal. Alternatively, organizational culture success factor will be included in the first, second, third, and fourth goal. The goals of the proposed instrument are listed as follows:

1. Improve the communication throughout the agile project.
2. Increase the customer involvement during the agile project.
3. Improve the training of the agile project team members.
4. Increase the support from top management in the agile project.
5. Enhance the delivery strategy.
6. Appropriate selection of agile techniques, practices, and PM approach.

A. Experts Interviews Design

This research applied semi-structured interviews encompassing open-ended questions and closed-ended questions to review the proposed instrument. The purposes of these interviews were: firstly, to review and confirm the proposed instrument's goals, questions, and metrics, and secondly to suggest any other questions and metrics that need to be considered when measuring the success of an agile software development project. The experts' interview process comprised many steps, which were as follows:

•Emails were sent to experts briefing them on the research and the objectives of the instrument. In the email, the experts were also asked to identify their preferred date and time for the interview.
•Depending on where the experts lived, some interviews were conducted online via Skype and Zoom, which are video calling applications. In contrast, other interviews were conducted on a face-to-face basis.
•Prior to the start of the interviews, all participants were requested to read the participant information sheet, following which they were asked to sign the consent form and return it by email.
•The participants were shown the instrument, and then had the opportunity to ask for further explanation if needed. This lasted approximately 5-10 minutes.
•Following this, the experts were asked about each goal in the instrument, starting with the first goal and ending with the last one. The experts were also asked about each item in the instrument and whether they felt that any additional item(s) needed to be added to the instrument.
•In the last part of the interview, the participants were asked to answer open-ended questions concerning how the instrument could be improved. This allowed the researcher to ensure that, according to the opinions of the interviewed experts, different aspects of agility were addressed in the proposed instrument. This also made it possible to confirm whether or not, according to the experts' interviewee responses, additional items were needed.
•The interviews were recorded and lasted, on average, approximately 35-60 minutes.
•The interviews were voice-recorded and summarised by the researcher using a pen and notebook. However, one participant refused to have his voice recorded, and that interview was hence not recorded.

VI. Instrument Review

This study applied semi-structured interviews encompassing open-ended questions and closed-ended questions to review the proposed instrument. The aims of these interviews were: firstly, to review and confirm the proposed instrument's goals, questions, and metrics. Secondly, to suggest any other questions and metrics that need to be considered when measuring the success of an agile software development project. Therefore, interviews were conducted with 13 agile experts where the instrument was shown to them in order to review the proposed instrument.

The experts' interviews resulted with many modifications to the proposed instrument. Following the received feedback, the instrument was revised accordingly. These modifications ranged from some language and editing notes to additional questions and metrics to be added. There were number of amendments which were applied to the proposed instrument to address the received feedbacks. It is difficult to list all the discussions with the agile experts about the instrument in this paper. Alternatively, the final version of the instrument is provided. The focus will be shifted now on how the proposed instrument could be validated. The researchers intended to use the instrument in three case studies. The evaluation obtained as a result of these case studies will make it possible to validate the practical usage of the instrument.

The final version of the proposed instrument after the review from the interviewed experts is shown in Tables I, II, and III. The separation of the instrument into three tables is only for presentational purposes.

TABLE I. THE PROPOSED INSTRUMENT (PART 1 OF 3)

Measuring the Success of Agile Software Development Projects	
1st Goal: Improve the communication throughout the agile project	
Q1. Rate your use of the ready communication platforms across the team (e.g. Slack, etc.) or your own developed platform?	• Very Good • Good • Acceptable • Poor • Very Poor
Q2. Rate the team practice of daily meetings (physical or virtual) where the team sit together to discuss the project progress?	
Q3. Rate your use of centralized repositories to enable documents and knowledge sharing throughout the project?	
Q4. How often the project team is sharing and communicating development's aspects?	• Always • Often • Sometimes • Seldom • Never
Q5. How often the team have access to task boards (or smart boards) to communicate with co-located members and video conferences capabilities to communicate with different-located members?	
Q6. How often do you communicate informally (face to face communication) during the project when it is possible?	
2nd Goal: Increase the customer involvement during the agile project	
Q1. Rate the customers' participation in planning meetings, demos, retrospectives and how they contribute to the success of these events?	• Very Good • Good • Acceptable • Poor • Very Poor
Q2. Rate the response time (e.g. how fast they are) from the customers to development queries?	
Q3. Rate the commitment and the support of the customers in the project toward resolving development issues and difficulties?	
Q4. How often do the customers attend the meetings (planning meetings, demos, and retrospectives) when they are requested to do so by the project team?	• Always • Often • Sometimes • Seldom • Never
Q5. How often do the customers express their needs to the project team, or suggest improvement for enhancing the project to the team?	

TABLE II. THE PROPOSED INSTRUMENT (PART 2 OF 3)

Measuring the Success of Agile Software Development Projects	
3rd Goal: Improve the training of the agile project team members	
Q1. Rate the available training resources in covering all aspects needed by the project team members? Q2. Rate the appropriateness of the contents of the training received by the project team? Q3. Rate the participation (e.g. attending, supporting, and facilitating) of the project team members in the available training programs?	• Very Good • Good • Acceptable • Poor • Very Poor
Q4. How often did the project team members practice self-training (e.g. watching learning videos, attending webinar, etc.)?	• Always • Often • Sometimes • Seldom • Never
4th Goal: Increase the support from top management in the agile project	
Q1. Rate the role of top management support toward the success of the attended planning meetings, demos, and retrospectives during the project? Q2. Rate the role of top management support in facilitating development issues? Q3. Rate the role of top management support in expediting development issues? Q4. Rate the overall support (budget, time, resources, etc.) from top management in the project?	• Very Good • Good • Acceptable • Poor • Very Poor
Q5. How often are the top management involved in planning meetings, demos, and retrospectives when they are requested to be there? Q6. How often do the top management initiate or propose events (meetings, emails, requests, etc.) whenever it is necessarily to do so?	• Always • Often • Sometimes • Seldom • Never

In Tables I, II, and III each question is associated with the corresponding used metric. The developed instrument has been reviewed by 13 agile experts. These experts' interviews allowed the researcher to refine and improve the instrument. It is intended that the proposed instrument will be validated by conducting case studies to use the instrument. Three organizations agreed to use the instrument to measure the success of their agile software development projects. The instrument will be validated by these case studies and the participants' evaluations will make it possible for further improvement of the instrument. By conducting case studies, the researcher will be able to validate the proposed instrument. It is hoped that the evaluation from these case studies will generate further understanding about the concept of success in adopting agile software development practices.

TABLE III. THE PROPOSED INSTRUMENT (PART 3 OF 3)

Measuring the Success of Agile Software Development Projects	
5th Goal: Enhance the delivery strategy	
Q1. How long it takes to deliver a story point?	Story point cycle time
Q2. How much of the sprint's (or iteration) planned story points actually delivered by the end of the current sprint?	Sprint Burndown
Q3. What is the percentage of planned to delivered story points in the current release?	Release Burndown
Q4. What is your schedule efficiency (how fast you are progressing against the rate of progress planned)?	Schedule Performance Index (SPI)
6th Goal: Appropriate selection of agile techniques, practices, and project management PM approach	
Q1. Do the team use an existing agile method "off the shelf" without adjusting it to suit their needs?	Yes/No.
Q2. How often are the current knowledge and capabilities of the team are considered when selecting agile techniques, practices and PM approach? Q3. How often are the needs of the customers and top management considered when selecting agile techniques, practices and PM approach? Q4. How often do the team conduct retrospectives (sprint reviews) to discuss the improvement of the selection of agile techniques, practices and PM approach? Q5. How often do these retrospectives (sprint reviews) lead to a change in agile techniques, practices and PM approach?	• Always • Often • Sometimes • Seldom • Never

The proposed instrument followed a scoring scale with which the success of agile software development projects could be measurement. The scoring is set to be used as an indication of how the participants of the instrument are doing and how they could achieve the defined goals of the proposed instrument, and ultimately achieve success with agile software development projects. With regard to the scoring of the instrument, the final score will range from 0 to 6, whereby 6 is the highest score. The final score is a result of totalling the scores of the six goals, each goal's score ranges from 0 to 1, whereby 1 is the highest score for each goal. The score of each goal is a result of summing of the scores for each question (0

to 1) dividing by the number of questions in that specific goal. This means that each question has the same weight when calculating the goal's score. Eventually, every goal of the six goals has the same weight when calculating the final score of the instrument. The scoring of the instrument will make it easy for the organizations to know their weaknesses and strengths. For instance, if the scoring of the instrument resulted in 0.90 for communication goal and 0.50 for the delivery strategy goal, it will be obvious that the work should be shifted to improve the delivery strategy.

VII. Conclusion and Future work

In this paper, an instrument to measure the success of agile software development was proposed. The development of the instrument followed the GQM approach. Semi-structured interviews were conducted with agile software development experts. These experts came from different industries and from different countries. The criterion with which the experts were chosen is that each expert must have at least five years of experience with agile development. The instrument was shown to 13 agile experts. Following this, the instrument was revised and amended based on the feedback received from the experts. The final version of the instrument comprised of 6 goals, 30 questions, and 7 metrics.

With regard to the future work, it is intended that this instrument will be applied in three organizations. These organizations will be used as case studies to apply the instrument. In each case study, the data regarding the agile software development will be gathered and the instrument will be filled. The instrument's score of the agile success will be provided to the organizations. During the case studies, there will be an evaluation of the use of the instrument and how the instrument could be improved. The three organization have been identified and contacted regarding this manner and they approved to host the case studies. By conducting these case studies, the instrument will be validated and further improvement might be added to the instrument.

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