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PRODUCTIVITY FACTORS IN AGILE SOFTWARE DEVELOPMENT PROJECTS

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Abstract

Agile methodology is the state-of-the-art methodology for software development projects. Important point for successful managing of agile software development project is precise project effort estimation. Productivity of agile team and team member significantly affect the accuracy of the estimation. In the literature, there are works dealing with even over 200 factors that can affect the productivity. This paper gives a literature overview of productivity factors. These works are mostly team productivity oriented and classified team productivity into different areas. Further, the paper suggests 18 factors as personal productivity factors for developers in agile software development teams. Each of these 18 factors has one value on a three-level weight scale.

Keywords: agile software development; software effort estimation; productivity factors; team and personal productivity.

1. Introduction

To adapt to constantly changed environment conditions, companies utilized lean management as a systematic approach for identifying and eliminating waste in their core processes. [1], [2] As a result of successful implementation of lean management in software processes, Agile Software Development (ASD) methodologies were created. Agile methodologies are the state-of-the-art methodologies for software development projects. However, the estimation of project effort, duration, cost, and product quality is a big challenge for ASD. [3] Using traditional estimation techniques (e.g. functional analysis, planning poker, etc.) can produce imprecise estimates. [4] Some recent studies show that estimation methods can successfully introduce Artificial Intelligence (AI) techniques for improvement of these methods [5], [6], [7].

An important element to assess in today's software estimations is productivity – both team productivity and individual team member productivity. It is not easy to identify factors that affect a productivity. And when they are even recognized, it is difficult to measure them.

Matos et al. [8] include 'team productivity' on the comprehensive list of 90 factors influencing effort estimation. Recognising important productivity factors and their interrelationships will enable project team management to identify areas where more effort is needed to improve effort estimates and overall project goals. Even when productivity factors are identified, it is difficult to set measurable criteria for their impact on productivity because such 'measurement' is largely subjective.

The rest of this paper is structured as follows: a literature overview regarding productivity factors (Section 2); a suggestion of personal productivity factors in agile software development projects (Section 3); and the presentation of conclusions and the outlines of future work (Section 4).

2. Related work

2.1. Productivity in general

Productivity generally indicates success in carrying out some work in relation to the resources used. [9] Jørgensen [10] emphasizes importance of 'productivity of the individuals or teams completing the work'. Jones [11] identified over 200 factors affecting the productivity of developers and software quality, and lists the primary factors that have the greatest impact:

- the skill and experience of staff,
- the cooperation of users during requirements and design,
- schedule or resource constraints,
- methods employed on the project,
- tools available,
- appropriate choice of programming language(s),
- problem complexity,
- code complexity,
- data complexity,
- project organization structures, and
- physical environment.

2.2. Team productivity factors

There is more research in the literature on factors affecting team productivity than on individual productivity. Factors related to developer productivity are rarely highlighted or the developer is seen as part of a team.

The study [12] describes research made in middle (> 30 developers) and large companies put also ‘agile teamwork productivity’ into the focus. It also claims that, from the perspective of agile team members, the four most perceived factors impacting on their productivity are:

- team effectiveness,
- team management,
- motivation, and
- customer satisfaction.

A study [13] identified 101 human factors and 79 influences influencing the individuals, the development team, and the software project activities. The authors concluded that the most investigated human factors in software development teams are:

- communication,
- collaboration,
- knowledge, and
- motivation.

A systematic mapping study [14] included 616 studies and identified 63 productivity factors that contribute to the measurement of team productivity in ASD. A systematic literature review [15] included 53 primary studies with the aim to identify and classify the factors influencing teamwork productivity in ASD. As a result, review identified 77 influential factors and classified them into six groups that affect teamwork productivity in ASD:

- technical,
- non-technical,
- organizational,
- environmental,
- project management, and
- user requirements.

2.3. Personal productivity factors

Some developers in a team can be multiple times more productive than the others with similar background and experience. The productivity of developer can enhance the productivity of the whole software development team.

Interesting correlation between needed soft skills (s. Table 1), big-five human traits, and developer's tasks through the whole software life cycle (SLC). These matrices can be good template for managing developers in the teams because they commonly work in a team. [16]

Big-Five Personality Traits	**Phases of SLC**	**Skill Description**
1. Openness	1. Requirement Analysis	1. Communication Skill
2. Conscientiousness	2. System Design	2. Interpersonal Skills
3. Extraversion	3. Implementation	3. Analytical & Problem-Solving Skills
4. Agreeableness	4. Testing	4. Open and Adaptable to Changes Skills
5. Neuroticism	5. Deployment	5. Organizational Skills
	6. Maintenance	6. Team Player Skills
		7. Ability to Work Independently Skills

Table 1. Personality traits, phases of SLC, and developer soft skills [16]

In the study made across three large USA companies researchers surveyed 622 developers about personal productivity factors and about self-rated productivity. They identified 48 factors, and the three most statistically significant among them in all three companies are [17]:

- job enthusiasm,
- peer support for new ideas, and
- useful feedback about job performance.

3. Productivity in small agile software development projects

Individual developer productivity is especially important in smaller teams and micro/small software companies because it has a greater impact on the project than in larger teams and large companies. An important node in the models for task effort estimation in ASD is 'Developer skills.' [18], [19] This node represents productivity of each team member involved in the project and whose productivity the project manager must evaluate when planning and managing the project. Even when such models are reliable, this node can be a source of instability, i.e. unreliability because it is a 'human' factor in the model.

Parameters used for calculation of an individual team member personal capability (s. Table 2) can be candidate for factors influencing above mentioned node. [9] They are, in fact, *personal productivity* factors. These factors are focused either on the experience or the personality of a developer. They can be used both as personal productivity factors and as team productivity factors.

Factor	***Factor description***
F1 – Work experience	Number of years of experience in similar jobs.
F2 – Knowledge of technology	Level of knowledge and handling of technology in which the software will be developed.
F3 – The level of learning and work habits	Adoption of new working procedures as part of the work being performed. It is reflected in self-acceptance and performance of the procedures.
F4 – Ability to work autonomously	Extent to which tasks are performed in accordance with the general or specific guidelines and instructions of his superiors and the scope of control superiors required in performing a particular job.
F5 – Work complexity	Level of complexity of the tasks performed in the workplace and the complexity of the procedures that apply in their resolution, the required level of personal contribution of employees and the scope of the workplace
F6 – Attitude towards work	Extent to which the employee identifies with the project in which it participates, how relaxed or seriously certain situations, and how it relates to the daily work in terms of their engagement.
F7 – Concentration	Degree of person's presence in the work that is done. Manifested by jumping from one job (or other content) to another or the commitment to carrying out the task.
F8 – Skill of performing of work types	For each task defines the kind of work it belongs, and each person has evaluated the performance of skill for any type of work.
F9 – Knowledge of the project	Knowledge of the project plan and involves participation in the planning of the project from the very beginning.
F10 – Knowledge of the product	Knowledge of the entire system, not just the knowledge of the individual segments.
F11 – Responsibility and influence on decision making	Extent to which the tasks performed in the workplace have an impact on the implementation of the project objectives.
F12 – Communication	It reflects the type and frequency of contacts that are achieved when performing tasks, and their importance to the project.

Factor	*Factor description*
F13 – Agility	Agility reflects the degree of dexterity and diligence in the performance of individual tasks.
F14 – Producing bugs	It manifests itself as a number of bugs produced during development but also in the time spent on the removal of bugs produced.
F15 – Knowledge of the area	Extent to which person needs consulting about business area.
F16 – Testing during development	Degree of effort required to test components developed by person, in order to reduce the number of bugs produced.
F17 – Experience in similar tasks	A measure that shows how person is experienced in performing similar tasks.
F18 – Need for supervision	Extent to which person needs daily mentoring by the project manager and / or head of software product development.

Table 2. Personal productivity factors, adapted from [9]

A general difficulty in working with productivity factors is the difficulty in measuring them. These factors do not contribute equally to productivity. A three-levels scale proved to be sufficient for the quantifying the capabilities of developers [9]:

- f = 10 – very important factor with the greatest impact on productivity,
- f = 8 – medium important factor that has a pretty big impact, but not decisive,
- f = 5 – factor that is not crucial but it would be good to have it.

Three-levels scale of weight factors and their numerical values (in this case: 5, 8, 10) are based on the author's practical experience in 13 years capability and productivity monitoring in small agile teams. [9], [20], [21] The number of levels and values of weighting factors should be adjusted by the company to its specific needs and environment.

4. Conclusion

An important step in the management of agile software development projects is the estimation of project efforts, costs, and quality. An important component of the estimation is the productivity of the team and project team members. When the factors affecting productivity are recognized, management can try to quantify them and then effectively manage them and the entire project.

This paper gives an overview of literature of productivity factors. These works describe more team productivity factors then personal productivity factors. In this paper 18 factors influencing personal productivity in small agile software development projects are described and suggested for use in such projects. A three-level weight scale based on experience for these 18 factors is also described and suggested.

In their future work, the authors will engage in deeper research into the connection between factors of personal productivity and estimation models in agile software development projects.

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6. References

[1] Softic, A., Basic, H.,, Lulic, H. & Nakic, A. (2020). Application of the Lean Concept for Analysis and Optimization of the Automobile Filter Production Company, Proceedings of the 31st DAAAM International Symposium, pp.0708-0716, B. Katalinic (Ed.), Published by DAAAM International, ISBN 978-3-902734-29-7, ISSN 1726-9679, Vienna, Austria DOI: 10.2507/31st.daaam.proceedings.098

[2] Trebuna, P.; Pekarcikova, M.; Kliment, M.; Kopec, J. & Svantner, T. Online e-Kanban System Implementation in a Manufacturing Company, International Journal of Simulation Modelling Volume 22: Number 1: March 2023, pp. 5-16

[3] B. W. Boehm, "Software Engineering Economics," in IEEE Transactions on Software Engineering, vol. SE-10, no. 1, pp. 4-21, Jan. 1984, doi: 10.1109/TSE.1984.5010193.

[4] Canedo, E.D., Da Costa, R.P. Methods and metrics for estimating and planning agile software projects, (2018) 24th Americas Conference on Information Systems 2018: Digital Disruption, AMCIS, New Orleans, 2018, ISBN: 978-099668316-6

[5] Rodríguez Sánchez, E.; Vázquez Santacruz, E.F.; Cervantes Maceda, H. Effort and Cost Estimation Using Decision Tree Techniques and Story Points in Agile Software Development. Mathematics 2023, 11, 1477.

[6] BaniMustafa, A. Predicting Software Effort Estimation Using Machine Learning Techniques. In Proceedings of the 2018 8th International Conference on Computer Science and Information Technology (CSIT), Amman, Jordan, 11–12 July 2018; pp. 249–256.

[7] Cabral, J.T.H.; Oliveira, A.L.I. Ensemble Effort Estimation using dynamic selection. J. Syst. Softw. 2021, 175, 110904.

[8] O. Matos, T. Conte, E. Mendes, „Is there a Place for Qualitative Studies when Identifying Effort Predictors? A case in Web Effort Estimation,“ Proc. of the 18th Int. Conf. EASE '14 40, May 13 – 14 2014, London, England, ACM Article No. 40

[9] Celar, Stipo : Turic, Mili : Vickovic, Linda, Method for personal capability assessment in agile teams using personal points // 22nd Telecommunications Forum/ / Paunović, George (ur.). Beograd: Institute of Electrical and Electronics Engineers (IEEE), 2014. str. 1134-1137.

[10] M. Jørgensen, “What We Do and Don’t Know about Software Development Effort Estimation,“ IEEE Software, vol 31(2), 2014, pp. 37-40

[11] C. Jones, “Applied Software Measurement: Global Analysis of Productivity and Quality,” 3rd ed, McGraw-Hill, Inc. New York, USA, 2008

[12] I. Fatema and K. Sakib, Factors Influencing Productivity of Agile Software Development Teamwork: A Qualitative System Dynamics Approach, 2017 24th Asia-Pacific Software Engineering Conference (APSEC), Nanjing, China, 2017, pp. 737-742, doi: 10.1109/APSEC.2017.95.

[13] E. Dutra, B. Diirr, and G. Santos, “Human Factors and their Influence on Software Development Teams - A Tertiary Study,” Sep. 2021, pp. 442–451. doi: 10.1145/3474624.3474625

[14] Guerrero-Calvache, M., Hernández, G. (2022). Team Productivity in Agile Software Development: A Systematic Mapping Study. In: Florez, H., Gomez, H. (eds) Applied Informatics. ICAI 2022. Communications in Computer and Information Science, vol 1643. Springer, Cham. https://doi.org/10.1007/978-3-031-19647-8_32

[15] Javed Iqbal, Azman Yasin and Mazni Omar, "Defining Teamwork Productivity Factors in Agile Software Development," *International Journal on Advanced Science, Engineering and Information Technology*, vol. 12, no. 3, pp. 1160-1172, 2022. [Online]. Available: http://dx.doi.org/10.18517/ijaseit.12.3.13648.

[16] M. A. Iqbal, A. R. Aldaihani, A. Shah, “Big-Five Personality Traits Mapped with Software Development Tasks to Find Most Productive Software Development Teams,” IJITEE, vol. 8, no. 12, pp. 965–971, Oct. 2019, doi: 10.35940/ijitee.J9755.1081219.

[17] E. Murphy-Hill et al., "What Predicts Software Developers’ Productivity?," in IEEE Transactions on Software Engineering, vol. 47, no. 3, pp. 582-594, 1 March 2021, doi: 10.1109/TSE.2019.2900308.

[18] Dragicevic, S.; Celar, S.; Turic, M. “Bayesian Network Model for Task Effort Estimation in Agile Software Development.” J. Syst. Softw.-Elsevier 2017, 127, 109–119.

[19] Turic, Mili, Stipe Celar, Srdjana Dragicevic, and Linda Vickovic. 2023. "Advanced Bayesian Network for Task Effort Estimation in Agile Software Development" Applied Sciences 13, no. 16: 9465. https://doi.org/10.3390/app13169465

[20] S. Čelar, Ž. Šeremet, Ž. Marušić, M. Turić, “Using of Web Objects Method in Agile Web Software Projects,” Proceedings of 21st TELFOR, Beograd, IEEE, 2013, pp. 873-876

[21] S. Čelar, V. Vicković, E. Mudnić, “Evolutionary Measurement Estimation Method for Micro, Small and Medium-Sized Enterprises Based on Estimation Objects,” APEM, vol 7(2), 2012, pp. 81-92