Adopting Augmented Reality for the Purpose of Software Development Process Training and Improvement: An Exploration

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Abstract. Augmented reality (AR) is a technological field of study that bridges the physical and digital world together with a view to improving user experience. AR holds great potential to change the delivery of software services or software process improvement by utilizing a specific set of components. The purpose of this exploratory study is to propose an integration framework to support AR for improving the onboarding process, notably in introducing new hires to the development process while performing their daily tasks. In addition, it also aims to enhance the software development workflow process using AR. Similar to a GPS device that can guide you from point A to point B, our goal is to create software artifacts like navigation components where software teams may benefit from digitally enhanced working conditions provided using AR. After conducting a review in the literature, we confirmed that there is lack of studies about the combination of augmented reality with software engineering disciplines for onboarding. In this paper, we formalized our approach based on the benefits of AR. Ultimately; we propose an AR-based preliminary model for improving the software development process.

Keywords: Software development · Augmented reality · Virtual dashboard

1 Introduction

Regarded as one of the emerging technologies, *Augmented Reality* (AR) enriches the real world with digital information and media, and should reshape the ways we interact with our environment. According to Azuma [1], AR is a technology, which combines the physical world with *virtual objects* for a new kind of visualization that promises spatial interaction in real time. The studies about AR were initiated in the 1960s [2] and

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the interest of people for this technology increased after the success of the Pokemon GO [3] game in 2016, which is almost 40 years after AR studies are started. Within the last two years, social media conversations about AR have gone up to a rate of 33% [4]. Recently, AR has become a promising technology that is used in various fields such as education, industry, entertainment, and military. Still, the current AR market can be considered as newly growing environment, meaning that technology and market maturity are still in their early adolescence [4]. However, AR technology still continues to progress. Up to now, it has valuable contributions in the fields in which it was used. In the light of these positive feedbacks, this technology can have promising impacts on different domains as well.

The goal of the study is to provide *continuous onboarding* (i.e. organizational socialization) to software practitioners and enhance the daily workflow of software organization, which make them productive members of software development organization. Specifically, we contend that it should be possible to continually use AR infrastructure as *an interactive mechanism* to continually train and educate process actors, rendering onboarding a continuous as opposed to a discrete (or even once-off) event. While performing their daily tasks, practitioners should collect information from a variety of different sources. Here, our aim is to visualize this information using AR technology by creating a virtual war room for stakeholders. Consequently, we improve the software development process in an AR enhanced environment with the motivation of producing software artifacts in a short amount of calendar time. This approach enables clear and quick communication and collaboration among teammates by having multiple resources to consume in a meeting room, creating a multiple data-feeding environment where software development issues can be quickly identified and resolved with less distraction with personalized enhancement of the workflow. The remaining part of the paper is organized in the following way: Sect. 2 gives a brief overview of Augmented Reality in the literature. In Sect. 3, we describe the AR framework, and finally, Sect. 4 concludes with the implication of the findings for future research.

2 Augmented Reality in the Literature

Thus, far, research has been conducted to explore the benefits of AR in education. One study by Wojciechowski and Cellar [5] highlights that students tend to collaborate AR objects with real objects by using simple and cost-effective devices. Freitas and Campos [6] developed an AR application called SMART (System of Augmented Reality for Teaching) to visualize and introduce objects such as cars, airplanes, and animals to primary school students. Application was experimented upon 54 students in three different schools, and the results showed that SMART improved their ambition towards learning. AR is not only used for primary level students, but also for higher level educated students in universities and colleges to embody complicated theories and systems [6]. In biology lessons, an AR application that simulates the organs in the human body with their names and explanations is used as a demonstration for the students for a more realistic experience in classroom [6].

One of the fields in which AR can be used efficiently is tourism. Kounavis et al. [7] mention some of the AR applications for this field in their research. Tuscany+, the *first*

AR application, is a digital tourist guide in the Tuscany region. Augmented Reality for Basel which is also a special tourist guide for the city of Basel, gives its users valuable information about the city, and users can find information about museums, hotels, shopping centers, restaurants, events, etc. Urban Sleuth is another example of AR application in tourism, but it is remarkably distinctive from the others because it requires user participation/interaction in order to solve mysteries and accomplish missions while touring in the city and competing with other teams. A final application is especially designed for the demands of the Museum of London and it is called The *StreetMuseum*. It enables users to view historical places and information about them [7]. Research highlights the importance of AR technology in tourism by emphasizing that industry of tourism needs to draw the attention of people and nowadays the most efficient way to achieve this is through the usage of mobile devices, therefore tourism industry must be kept updated by new investments [8].

Carmigniani et al. [9] express that using AR in the entertainment industry may bring a breath of fresh air into it, especially for the gaming, for instance, animations can be displayed when playing a board game. With AR technology, the user experience of players can be improved. *Augmented onboarding* can be beneficial as a main component of a game, e.g. presenting how to play, showing tactics that are available, displaying ongoing characteristics of other players. Such a visual improvement makes games more attractive and interactive. As an example, Gandy et al. [10] developed AR Karaoke game. The game allows the player to play a scene from a movie. A HMD (head-mounted display) is used for getting into the environment of the scene with virtual objects. The gamer can experience the movie scene in first-person perspective. Yuen et al. [11] investigated AR technology in marketing with giving the example of automotive companies, which use real size AR virtual cars in their showrooms. With virtual buttons, customers can observe virtual model vehicles by opening doors and rotating them. They indicate that customers can gain more definite impression about the product with using the virtual models on their mobile phones. Augmented Reality is commonly used for online advertising. As an example, the car company MINI [12] developed an AR application advertised in some German magazines. In this special form of advertisement, readers show the related page to their webcams and a virtual MINI car appears on the screen [9]. Magic mirror is also an application of AR technology developed for marketing. In addition to this, Cisco's fitting room is another development for retail sales which involves AR technology. In these two applications, customers are allowed to try on virtual clothes instead of real products. With AR technology, they see how such clothing might look on them. This helps customer to make more accurate decisions during shopping [9]. Furthermore, Höllerer and Feiner [13] mention that in the future, virtual billboards may appear on the street, according to user's profile and interests to advertise a product and as a result, that would catch the attention of marketing agencies, since it would increase the customer interest in such products. In the light of these examples and tendency to using mobile technologies in every area like shopping, marketing is one of the fields that have a significant potential for AR technology investments.

In addition, AR is suitable for training military personnel. One usage of AR for military is tracking medical issues on a battlefield. The authorized commander in combat can get the information about the health status of a soldier, whether he is

injured and visualize the view and conditions of the field using AR [13]. Special AR helmets that contain 360 cameras and sensors are in developing phase to help ground soldiers to experience real life combat conditions with the warnings about the battlefield conditions such as an enemy or a danger spot warning [11]. In their study, Fenier and Henderson [14] developed an AR system that provides system and equipment maintenance to bulletproof vehicle to make the repairment more quickly and securely, by a military mechanic wearing special AR glasses.

Automotive industry is one of the sectors in which AR has a potential. Many of the companies, especially car and airplane manufacturers, work with some big, costly, fast changing and time-consuming products. Consequently, producing this kind of products and training people to learn and assemble the parts of products require large amount of time and money. Reiners et al. [15] mentioned that since the products change faster and companies need to keep pace with the new technologies, AR can be used for training the service personnel in assembling and fixing the parts of a product. In their study, they worked with BMW Company in the assembly of a door lock into a car door. As a result, their work enlightened prototyping and conducting tasks in a specific part of a car. Furthermore, Azuma [1] stated that a 3D model that simulates the real components of equipment is easier and more practical rather than manuals and pictures for following instructions. Boeing, one of the largest airplane companies, uses AR technology to guide the technicians around the electrical system of an airplane. Moreover, Feiner [16] claimed that architects can use AR to visualize the installation of a building by showing the electric cables and pipe systems inside the walls. Also, it can be used to display the view from a window of a building that is in planning for the architect to see and analyze. After examining the priorities for different sectors, AR can be implemented or adapted according to the demands of that industry.

2.1 Onboarding

Onboarding is the process of incorporating new employees into an organization [17]. Onboarding, in other words adaptation process of getting used to the company culture, new colleagues, and new projects, takes some time; however, it is becoming easier with certain methods and tools [18]. Unmistakably, AR gives entrepreneurs boundless potential for putting learners in realistic situations and circumstances. Numerous representatives learn best by doing as opposed to seeing. A new approach to the onboarding process is continuous onboarding, in which the adaptation period never stops. It continues as the employee works in the company and it keeps him/her engaged in the working process. According to Leaman, the employees who have had a successful onboarding experience are more likely to stay with a company for a long period [19]. Yates [20], claimed that the onboarding process is crucial for developers, who work individually or work in a team, in order to understand the techniques, culture and the code based work in the company. It is better to get the information about coworkers, documentation, codes and code artifacts by new employees to make the onboarding process more qualified.

The business world is living and changes rapidly. Therefore, sustaining business agility and adaptability is crucial for being afloat in the sector. Taking these facts into consideration, companies work on real-time continuous training [21]. The software

development industry is one of the most challenging industries in terms of employee adaptation to a job. Technology giants like Google, Apple, Microsoft are aware about this issue and are therefore investigating solutions regarding this issue. Recently, Apple created an AR application in which while walking around campus they orient their new employees by showing how each department works using AR [22].

To sum up, AR technology has a great potential in many different fields, such as education, tourism, entertainment, marketing and sales, military, and automotive industry as it can be seen in Fig. 1. It shows how the conversations in AR has changed from 2015 up until the 3rd quarter of 2017 in various fields. Regularly, technology is evolving and applications are getting more visualized and becoming more interactive.

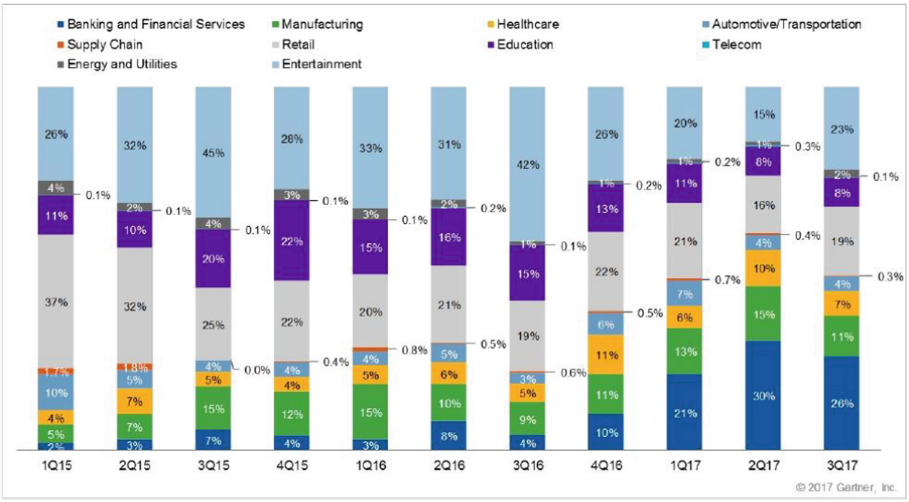

Fig. 1. Verticals driving the social media conversations in AR [23]

AR technology provides extended experiences to its users instead of flat screens, keyboards, and external components. It promises better connections to individuals with the data they want to access [24]. The ever-increasing evolution of mobile technology and the fast adaptation to these devices by people have allowed AR to become reachable to the public [25]. Recently, AR has been identified as a technology with promising advancements in application market. When all these workings about AR are taken into consideration, there is certainly, a lack of academic and scientific research on the combination of AR and Software Engineering disciplines, and also AR used for onboarding processes. The purpose of this project is to provide continuous onboarding to software practitioners, while performing their daily tasks. It would be possible by creating an enhanced version of spatial reality enriched by digital information and media. As a result, software development workflow would be improved by using this system. We believe that software developers should be interactively guided using such an AR technology. Therefore, we characterize an environment which includes AR for software development teams.

3 Augmented Reality Based Continuous Onboarding Framework

Software development is a process that has a deep background consisting of various phases. Even though, there are different methodologies used in software development, it has never been a straightforward process. Developers should always be highly motivated and continuously focused on the project. Otherwise, they can easily be disoriented during the development activities. All developers including juniors should always keep the pace of the process. By creating a combination of augmented reality (AR) and a software development workflow process, the goal of this project is to provide continuous onboarding to software practitioners, while performing their daily tasks. In addition, our plan is to visualize the profile of software practitioners, their skills, their performance and progression using AR technology. Ultimately, an aim is to collect information from a set of different sources and visualize it using AR. For the development, we have chosen Vuforia [26] integrated with Unity 3D platform [27] which is a game engine with 3D graphics and it is compatible with all different platforms and devices. Vuforia has been shown to be one of the leading augmented reality tools by developers, due to its remarkable features, such as compatibility with popular gadgets, visuals of different kinds, perception of objects. For the coding of the project, C# language is used in Visual Studio 2017 integrated with Unity 3D.

Figure 2, displays the information about the connections between system attributes. The system performs the task according to the modeID in AR Mode class. AR Mode class manages the mode that the system will work according to a user's selection. AR User class is the class that represents functions of the actor of the system. The user selects a mode and views the information about the object according to the type of the objects which are either another user or a meeting room. AR frame tracks environment in both modes. This class gets the information about scanned image and creates the augmented content. AR Anchor class is incorporated with AR Frame and according to the augmented content from AR Frame; it locates the content according to world location.

The framework consists of two main modules, which are the *user management module* and the *activity mode module*. The user management module contains the functionality of profile authorization, which controls and navigates users through system usage lifetime. The second module is the activity mode module, which comprises orientation mode and the war room mode of the system. These two submodules have their own functionalities as environment tracking, positioning and orientation of real world data and mixing virtual content. In augmented reality, we change the real world data by adding some virtual data and represent this mixed content to the user. The AR mechanism begins to work by getting the real world data through camera or sensors. After that, positioning and adaptation are done and data is ready for processing. The processing of the data is the most crucial part for developing the AR application. Changing the real world data is done in this step and mixed with virtual information. In the last step, content of mixed reality is represented to the user as video output. This part of the framework is planned to be available for company workers only. Standard users are the practitioners who are working on software development.

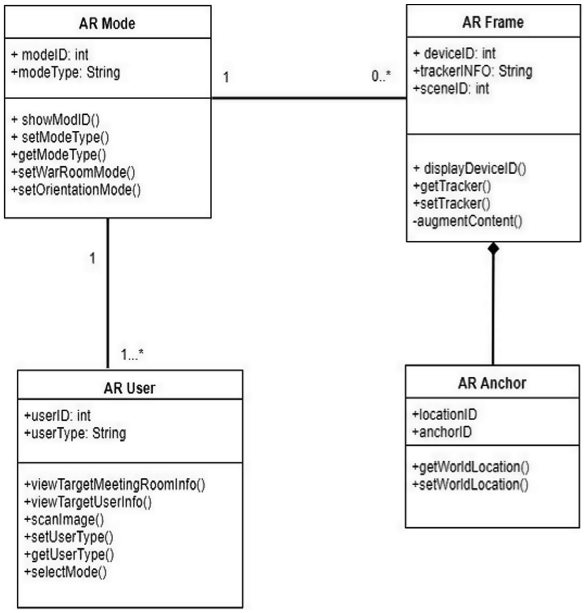

Fig. 2. Class diagram of the proposed framework

Developers can login, use orientation and war room mode, and exit from the system. First, the user should run the application and the login page is opened. The user is expected to be registered to the system by the system administrator, who manages the database of the company so that she can login to the system. By inputting a valid username and password, the user logs in to the system and is navigated to the related page according to her authorization rights. Developers can navigate to the mode selection page, from which they can continue with either orientation mode or war room mode.

3.1 Orientation Mode

In this mode, the users can access the profile information of a developer by scanning the unique image which belongs to the selected developer. The participant must be logged in and switched to the orientation mode before accessing. The camera screen is opened and the environment can be observed from the screen and application does environment tracking functionality. The user basically selects an AR target to get information about a person. After determining a target, the user scan the unique image which belongs to the target developer to get information about her/him. The user sees these information on the screen mixed with the augmented reality components. After information becomes visible, the user can scan a new image or can exit from the orientation mode by selecting exit option.

3.2 War Room Mode

In this mode, the user can access the information about the scrum board by scanning the unique image which belongs to the selected board. The user must log in and switch to the war room mode from the menu. Similar to Orientation Mode, camera screen is opened and the user sees the environment through the camera screen and the application tracks the environment. With scanning the unique image of the whiteboard in the room, the user can see the notes that are taken in the previous project meeting as "TO DO", "IN PROGRESS" and "DONE". Also, a progress bar can be seen to visualize the improvement of the development process of the project. The user can exit from the war room mode by selecting exit option.

To use the proposed *AR framework*, user chooses whether the application will be on "*Orientation Mode*" or "*War Room Mode*" by touching the screen. The user follows the office environment from the screen. If the system is on the *Orientation Mode*, the user looks for the identifier image on the employee's desk. When an image has matched from the database of the system, a virtual button will be seen to extend the information to the owner of the desk. If the user presses that button to extend, the first thing user sees is photograph, name, position, team, some personal information, specialty and current works of the person, that is the owner of the identifier image and position and department that he works in. If the system is on the *War Room Mode*, the user scans the identifier image on the scrum board to the camera. The options menu, to choose which

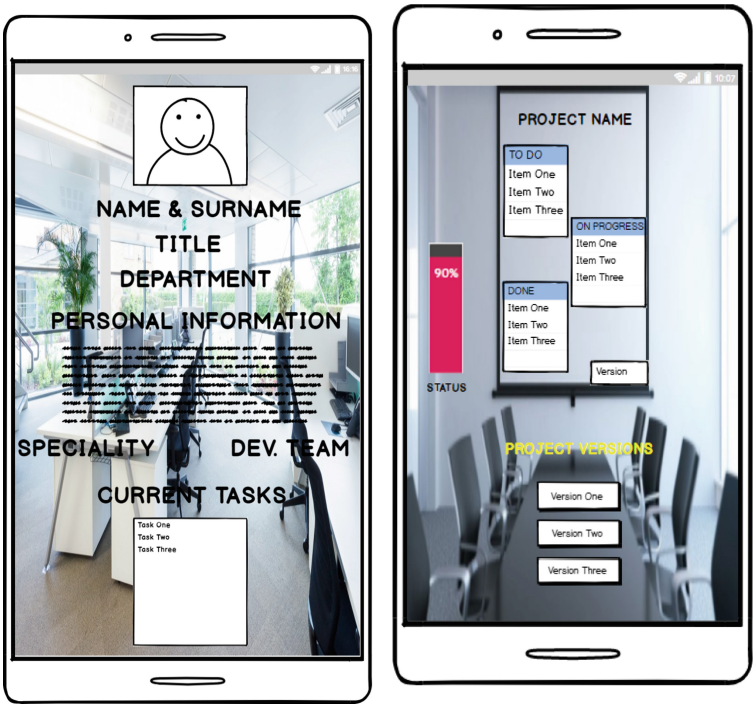

Fig. 3. Sample interface design from the orientation mode and the war room mode

meeting information to choose, is displayed on the screen. Options are shown as meeting name and meeting date. After the user chooses the meeting, meeting information is shown as project name, version of the project, and scrum board information is displayed on the whiteboard of the meeting room through the camera screen.

In the *Orientation Mode*, when the user scans the unique image of some colleague and continues with the show information button, a window like Fig. 3 (left) appears, that has entries about the selected developer's photograph, name, title, department, team, some personal information, specialty and current works of the person. Figure 3 (left) is an interface sample that we prototyped to use as the general screen design when the target image of a developer is scanned and identified in the *Orientation Mode*. In the *War Room Mode*, when the user scans the unique image of the board, a window like Fig. 3 (right), that has the entries about the project name, version of the project, and scrum board information, is displayed on the whiteboard of the meeting room through the camera screen. Figure 3 (right) is the sample interface of the War Room Mode after the whiteboard is detected in the meeting room.

4 Discussion

An initial objective of the study was to identify the potential benefits of AR in software development. This study provides a novel approach to augment software practitioners' reality. The results of this study support the view that a complementary tool is beneficial for assisting software development not only in daily task arrangement but also for onboarding novice software practitioners. To this end, a preliminary model was designed and an initial prototype was created. The prototype was tested and evaluated by software engineers who are currently working in a software company and have different years of working experiences. From the feedbacks of these users, it is observed that some design components can be improved in the system. Overall, they generally thought that the tool can be functional and beneficial for the development teams and newcomers to the company. This study suggests that technological assistance tools for software development shall emerge after continuous integration becomes a more common practice.

We believe this work to be important for the broader software engineering community as there is a growing acknowledgement, that not alone is the software process complicated [28], but also that there are a large number of factors affecting the process [29–31] with the result that the overall business of software process engineering is subject to regular change and highly complex [32]. Added to these challenges in process enactment, we must strive for appropriate levels of process focus in organizations as increased process focus has been demonstrated to be positively associated with successful business outcomes [33]. Given these various acknowledgements, and the added rich variety of individual roles in software engineering [34], steps to improve process communication and process feedback/improvement (such as is enabled by our AR proposal) are considered to offer innovative mechanisms to assist in addressing the challenging software process space. We suggest that many software developers may have an intrinsic interest in VR and AR type activities, and in the past have demonstrated the power of VR in terms of improving process-learning outcomes [35], and in

assisting developers in presentation related training [36]. In this sense, the AR based research that we present herein can be considered to be a natural and important progression of our earlier work in this space [37].

Overall, this study suggests a model to assist software practitioners by using the latest technology, which also improves practitioner motivation, while performing routine activities. Consequently, the social structure of software organizations will be enhanced by emerging technologies. In future investigations, it might be possible to improve the software development process by successfully capturing the tacit knowledge in a software development organization as it is actively evolved and to feed this information into improved/adapted AR models, so that AR can become an integral part of process management for software teams, using technology that is aligned with the interest of many software developers.

References

1. Azuma, R.: A survey of augmented reality. Presence: Teleoperators Virtual Environ. **6**(4), 355–385 (1997)
2. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., MacIntyre, B.: Recent advances in augmented reality. IEEE Comput. Graph. Appl. **21**(6), 34–47 (2001)
3. Catch Pokémon in the Real World with Pokémon GO! Pokemongo.com (2017). http://www.pokemongo.com/. Accessed 22 Oct 2017
4. Nguyen, T., Jump, A., Resnick, M.: Three Key Development Practices to Implement Effective Enterprise Augmented Reality Applications. Gartner (2017)
5. Wojciechowski, R., Walczak, K., White, M., Cellary, W.: Building virtual and augmented reality museum exhibitions. In: Proceedings of the Ninth International Conference on 3D Web Technology, 5–8 April 2004, Monterey (2004)
6. Freitas, R., Campos, P.: SMART: a SysteM of augmented reality for teaching 2nd grade students. In: Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction, vol. 2, pp. 27–30. BCS Learning & Development Ltd. (2008)
7. Kounavis, C., Kasimati, A., Zamani, E.: Enhancing the tourism experience through mobile augmented reality: challenges and prospects. Int. J. Eng. Bus. Manag. **4**, 10 (2012)
8. Xiang, Z., Tussyadiah, I. (eds.): Information and Communication Technologies in Tourism 2014, pp. 511–523. Springer, Cham (2013). https://doi.org/10.1007/978-3-319-03973-2
9. Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., Ivkovic, M.: Augmented reality technologies, systems and applications. Multimed. Tools Appl. **51**(1), 341–377 (2010)
10. Gandy, M., et al.: AR Karaoke: acting in your favorite scenes. In: Proceedings of the 4th IEEE/ACM International Symposium on Mixed and Augmented Reality, pp.114–117, 5–8 October 2005
11. Yuen, S., Yaoyuneyong, G., Johnson, E.: Augmented reality: an overview and five directions for AR in education. J. Educ. Technol. Dev. Exch. **4**(1), 11 (2011)
12. The Official MINI Website—MINI UK, The Official MINI Website—MINI UK (2017). https://www.mini.co.uk/en_GB/home.html. Accessed 22 Oct 2017
13. Höllerer, T.H., Feiner, S.K.: Mobile augmented reality. In: Karimi, H., Hammad, A. (eds.) Telegeoinformatics: Location-Based Computing and Services. CRC Press, Boca Raton (2004). ISBN 0-4153-6976-2

14. Henderson, S., Feiner, S.: Exploring the benefits of augmented reality documentation for maintenance and repair. IEEE Trans. Visual Comput. Graph. **17**(10), 1355–1368 (2011)
15. Reiners, D., Stricker, D., Klinker, G., Müller, S.: Augmented reality for construction tasks: doorlock assembly. In: Proceedings of the International Workshop Augmented Reality (IWAR 1998), pp. 31–46 (1999)
16. Feiner, S., Webster, A., Krueger, T., MacIntyre, B., Keller, E.: Architectural anatomy. Presence: Teleoperators Virtual Environ. **4**(3), 318–325 (1995)
17. What Is Onboarding? - Best Practices & Process - White Paper, Icims.com (2017). https://www.icims.com/resources/white-paper/onboarding. Accessed 8 Dec 2017
18. Kosa, M., Yilmaz, M.: Gamifying the onboarding process for novice software practitioners. In: Kreiner, C., O'Connor, R.V., Poth, A., Messnarz, R. (eds.) EuroSPI 2016. CCIS, vol. 633, pp. 242–248. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-44817-6_20
19. 3 Tips to Redesign Your Onboarding Process into a Continuous Experience - eLearning Industry, eLearning Industry (2017). https://elearningindustry.com/redesign-your-onboarding-process-into-a-continuous-experience-3-tips. Accessed 8 Dec 2017
20. Yates, R.: Onboarding in Software Engineering (2014)
21. Newman, D.: Hyper-Training and the Future Augmented Reality Workplace (2017). https://www.forbes.com/sites/danielnewman/2016/09/20/hyper-training-and-the-future-augmented-reality-workplace/#33650a2728b0. Accessed 9 Dec 2017
22. Beus, B.: How Augmented Reality Can Revolutionize Employee Onboarding and Retention. Business 2 Community. https://www.business2community.com/tech-gadgets/augmented-reality-can-revolutionize-employee-onboarding-retention-01921335#shajp8sgjDJrGDKB.97. Accessed 9 Dec 2017
23. Resnick, M.: Best Practices for Using Augmented Reality in Mobile Apps. Gartner (2017)
24. Blau, B., Burke, B., Searle, S., Cearley, D.: Top 10 Strategic Technology Trends for 2017: Virtual Reality and Augmented Reality. Gartner (2017)
25. Nguyen, T., Blau, B.: Market Guide for Augmented Reality. Gartner (2017)
26. Vuforia Supported Versions, Vuforia (2017). https://library.vuforia.com/articles/Solution/Vuforia-Supported-Versions. Accessed 4 Dec 2017
27. Unity - Products, Unity (2017). https://unity3d.com/unity. Accessed 18 Nov 2017
28. Clarke, P., O'Connor, R.V., Yilmaz, M.: A hierarchy of SPI activities for software SMEs: results from ISO/IEC 12207-based SPI assessments. In: Mas, A., Mesquida, A., Rout, T., O'Connor, R.V., Dorling, A. (eds.) SPICE 2012. CCIS, vol. 290, pp. 62–74. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-30439-2_6. ISBN 978-3-642-30439-2
29. Clarke, P., O'Connor, R.: The situational factors that affect the software development process: towards a comprehensive reference framework. Inf. Softw. Technol. **54**(5), 433–447 (2012). ISSN 0950-5849
30. Marks, G., O'Connor, R., Clarke, P.: The impact of situational context on the software development process – a case study of a highly innovative start-up organization. In: 17th International Conference on Software Process Improvement and Capability determination (SPICE 2017), 4–5 October 2017, Palma de Mallorca (2017)
31. Clarke, P.M., et al.: Exploring software process variation arising from differences in situational context. In: Stolfa, J., Stolfa, S., O'Connor, R.V., Messnarz, R. (eds.) EuroSPI 2017. CCIS, vol. 748, pp. 29–42. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-64218-5_3. ISBN 978-3-319-64218-5
32. Clarke, P., O'Connor, R., Leavy, B.: A complexity theory viewpoint on the software development process and situational context. In: International Workshop on Software and Systems Process (ICSSP 2016), 14–15 May 2016, Austin (2016). ISBN 978-1-4503-4188-2
33. Clarke, P., O'Connor, R.: The influence of SPI on business success in software SMEs: an empirical study. J. Syst. Softw. **85**(10), 2356–2367 (2012). ISSN 0164-1212

34. Yilmaz, M., O'Connor, R., Clarke, P.: Software development roles: a multi-project empirical investigation. ACM SIGSOFT Softw. Eng. Notes **40**(1), 1–5 (2015). ISSN 0163-5948
35. Aydan, U., Yilmaz, M., Clarke, P., O'Connor, R.: Teaching ISO/IEC 12207 software lifecycle processes: a serious game approach. Comput. Stand. Interfaces **54**(Part 3), 129–138 (2017)
36. Nazligul, M.D., Yilmaz, M., Gulec, U., Gozcu, M.A., O'Connor, R.V., Clarke, P.M.: Overcoming public speaking anxiety of software engineers using virtual reality exposure therapy. In: Stolfa, J., Stolfa, S., O'Connor, R.V., Messnarz, R. (eds.) EuroSPI 2017. CCIS, vol. 748, pp. 191–202. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-64218-5_15. ISBN 978-3-319-64218-5
37. Yilmaz, M., Güleç, U., O'Connor, R., Clarke, P., Tüzün, E.: An industrial case study to improve the onboaring process in software management. Yazılım Yönetiminde İşe Alıştırma Süreçlerinin İyileştirilmesi İçin Düşünülmüş Bir Endüstriyel Vaka Çalışması. In: 11th Turkish National Software Engineering Symposium (UYMS 2017), 18–20 October 2017, Alanya, Turkey (2017)