

# Investigating the Adoption of Agile Practices in Mobile Application Development

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**Abstract:** The mobile application development market has been dramatically growing in the last few years as the complexity of its applications and speed of software development process. These changes in the mobile development market require a rethinking on the way the software development should be performed by teams. In order to better understand how agile practices support mobile application development, we applied a questionnaire to 20 undergraduate students. These students have been training in an iOS development course combined with agile practices. Our study aims to identify challenges and to report the students experience on the adoption of agile practices to develop mobile applications. Our findings reveal that agile practices help mobile software development mainly in terms of project management and control and development speed. However, aspects of user interface and user experience, different development platforms, and users expectations still point challenges in developing mobile applications.

## 1 INTRODUCTION

Mobile application development is a new trend in the software industry. It also plays an important role in the economic development of a country as well as in teaching and learning (Zhang, 2015). The combination of devices such as cameras, sensors, touch and GPS with mobile platforms increase the possibilities for developing new mobile applications (apps). Additionally, devices have become more complex and mission critical (Lewis et al., 2013) due to the sudden wave of mobile device use.

According to Wasserman (Wasserman, 2010), mobile devices have been adopted in different ways for desktop or laptop computers. Mobile applications development can be similar to software engineering for other embedded applications. However, mobile applications development present some additional requirements that are less commonly found if compared to traditional software applications. The relevance of mobile software products has reached a point in which its devices have become one of the most popular platforms for the distribution and use of user-oriented software (Corral, 2012). The development speed in mobile software development has become a key factor due to developers' possibility of submitting applications (apps) directly to the market. Thus, it is

necessary to identify agile practices to implement mobile applications as well as to provide a good learning experience.

In this paper, we investigate challenges in mobile application development and the students' experience on the adoption of agile practices for developing mobile applications. In order to achieve this goal, we applied a questionnaire to 20 undergraduate students who have been attending an iOS development course. This course adopted agile practices to develop different types of mobile applications. Our results describe the participants' perception on the use of agile practices, challenges, and perceived benefits. The main contribution of this paper is to provide a further discussion about the adoption of agile practices for mobile application development.

The remainder of this paper is organized as follows: Section 2 introduces a brief background about mobile application development while Section 3 presents a background on agile software development. In Section 4, we describe the research methodology adopted in this study and, in Section 5, we present the results. Section 6 discusses our results. Finally, we draw our conclusion and future work in Section 7.

## 2 MOBILE APPLICATION DEVELOPMENT

Since 2008, Apple and Google have opened their application store for iOS and Android platforms, a point where mobile apps started quickly evolve. Mobile application development is a process in which applications are developed for small handheld devices, being either pre-installed on devices during manufacture or downloaded from application stores or other software distribution platforms (Flora and Chande, 2013). Following the evolution of mobile application development, the traditional software development life cycle is no longer the only approach because long project planning phases and long development cycles can result on outdated mobile applications.

There are different programming environments available for the major mobile platforms (Wasserman, 2010), for Windows Phone there is Microsoft's Visual Studio environment, for Android platform there are Android development tools plug-in for Eclipse, and Apple iOS Dev Center has the Xcode package. According to Xanthopoulos and Xinogalos (Xanthopoulos and Xinogalos, 2013) with the currently increasing number of mobile platforms, developing mobile applications has become difficult for companies, as they need to develop the same applications for each target platform. The typical process for developing native applications is the most appropriate way of deploying mobile apps but it has one major disadvantage: it is not possible to reuse the source code for another platform; the same app must be redeveloped from the beginning.

Mobile web applications are mainly based on technologies such as HTML and JavaScript and do not require installation or device upgrades, enabling information processing functions to be initiated remotely on Web server (Huy and vanThanh, 2012). Some of the web applications drawbacks are: limited access to the underlying device as hardware and data and the extra time needed to render the web content (Xanthopoulos and Xinogalos, 2013). Hybrid development is another approach to develop a mobile application which tries to combine the advantages of web and native apps where applications are primarily built using HTML5 and JavaScript, and a deep knowledge of the target platform is not required (Xanthopoulos and Xinogalos, 2013). According to Alston (Alston, 2012), many mobile applications that are developed are considered to be alternative applications. These applications are developed for a specific platform and it have access to the hardware of a device through the use of Application Programming Interfaces (APIs).

The adoption of a suitable software development methodology is very important in mobile software engineering, since software applications are changing and evolving all the time based on immediate user requirements (Kaleel and Harishankar, 2013). Authors describe Scrum practices as the best suit requirements of android software development and applied them in designing a mobile software development methodology where they were able to successfully develop a secure backup application using important features from Scrum methodology such as adaptability to evolving requirements, technically strong development teams and effective communication through daily meetings (Kaleel and Harishankar, 2013).

## 3 AGILE DEVELOPMENT

Agile development or adaptive development are aimed to rapidly adapt to the changing reality. An agile method emphasizes communication and collaboration in an iterative process (Smite et al., 2010).

The adoption of agile development makes software processes more flexible, helps in continue learning and incremental delivery, quickly and easily adapting to requirements and technologies changes. Moreover, agile development focuses more on the human aspects of software engineering than the processes, human interaction over tools and processes (Flora and Chande, 2013). Authors also performed a review and analysis on mobile application development process using agile methodologies. According to authors agile development has fit for mobile application development. In this context, there are studies which recommended that agile practices are a good choice and assures different phases of software development life cycle to solve the mobile application development issues (Flora and Chande, 2013), they evaluated the following mobile development process: Mobile D, RaPiD 7, Hybrid Methodology Design, MASAM and SLeSS where they found that work related to mobile software confirms agile practices to be a natural fit for the development of mobile applications and an appropriate agile method could be selected for a given project and can be tailored to a specific requirement based upon project's complexity and team size.

Agile development is recommended to small-to-medium-sized projects, software development organizations are increasingly recognizing the need for agility.

In literature, Extreme Programming (XP) and Scrum are the most common agile methods for mobile application development. According to Paasivaara et

al. (Paasivaara et al., 2008) these methods can be easily customized by software companies. We describe these agile methods and others in the following subsections.

### 3.1 Extreme Programming

Extreme Programming (XP) is a discipline of software development which emphasizes productivity, flexibility, informality, teamwork, and the limited use of technology outside of programming, working in short cycles and every cycle starts by choosing a subset of requirements from a larger set (Macias et al., 2003).

According to Moore and Flannery (Moore and Flannery, 2007), XP implements a groupware style development where feedback is obtained by daily testing the software where developers deliver the system to the customers as early as possible, allowing a rapid response for requirements and technologies changes. Beck (Beck, 2000) present XP as a light-weight methodology for small-to-medium-sized teams developing software in the face of vague or rapidly-changing requirements.

### 3.2 Scrum

Scrum is an iterative and incremental agile software development approach. It offers a framework and set of practices that keep everything visible, allowing practitioners to know exactly what is going on and to make adjustments in order to have the project moving towards desired goals. The adoption of Scrum practices is the main factor to successfully develop software projects (Scharff and Verma, 2010).

The scrum workflow is a sequence of iterations called *sprints* which have a duration between one and four weeks each. The team has the work foundation as part of a product backlog which is a list of requirements and priorities.

Each sprint has daily meetings where each team member answers what he/she has been done on the previous day, what is going to be done in the current day and if there is any roadblock to move forward on development activities. At the end of each sprint there is a product demo called *Sprint Review* and after that it is handled a lessons learned session called *Sprint Retrospective* (Reichlmayr, 2011).

## 4 RESEARCH METHODOLOGY

We applied a questionnaire to a group of 20 students from the iOS development training course. This

course is provide for a large software company in order to train undergraduate students on mobile application development for iOS. The course takes 4 months duration.

In this study, we selected 20 from 87 students, who were attending the course. We adopted a random selection to obtain a pool of participants.

During the course, each student has his/her own equipment to use as part of the class meetings and projects and worked in teams from two to five individuals. The course curriculum includes the following subjects: Object-Oriented Programming, User Interface (UI) components, Model View Controller, Data sources, Navigation, Animations and Frameworks. The course also covered an introduction to Scrum framework. After taking theoretical lessons, all students work for four months to develop real mobile applications using agile practices to support it.

The participants are on average at the 5th semester and majority of participants who answered the questionnaire are from an IT related field: 30% from Computer Science, 35% from Information Systems, 10% from Computer Engineering, 10% from Systems Analysis and 15% from Other courses.

Another profile information from the overall 87 students attending the training is that 35% of the students already had previous software development courses using Java and C#. In this context, 68% had up to 3 years of experience in development, 18% had between 3 and 5 years of experience, and 14% had more than 5 years software development experience. Only 10% of the students had a previous contact with mobile application development. Most of previous students experience were from other courses, as well as from the industry. In the software development methodology analysis, 65% did not have any previous contact with software development methodologies, 20% had previous contact with some practices of agile development, and 15% had contact with traditional software development approach. Table 1 present the participants information.

The course is facilitated by 6 instructors with experience in iOS development, academic and project management background. Four of them, have more than five years of experience as software developers. The course combines elements of Challenge-Based Learning (CBL) and Scrum in order to help the students to develop their apps (Santos et al., 2015).

At the end of the training course, we applied a questionnaire with eight research questions. Six questions to collect the background information of the participants (Name, Age, Undergraduate course, Semester, Previous working/study experience in agile practices, Previous working/study experience in mo-

Table 1: Participants information.

Participant	Age	Course	Semester
A	24	Computer Science	8
B	23	Information Systems	6
C	21	Computer Engineering	5
D	22	Information Systems	7
E	27	Information Systems	5
F	21	Information Systems	4
G	24	Computer Science	3
H	22	Information Systems	5
I	19	Information Systems	4
J	21	Computer Engineering	5
L	34	Systems Analysis	3
M	19	Information Systems	5
N	20	Computer Science	4
O	20	Computer Science	3
P	26	Computer Science	4
Q	20	Business	5
R	24	Systems Analysis	3
S	21	Engineering	9
T	22	Systems Analysis	7
U	24	Computer Science	5

bile development). The other two questions related to the adoption of agile practices to develop mobile applications. The following questions are presented:

- Q1: *What are the challenges in mobile application development?*
- Q2: *What is your opinion about the adoption of agile practices for mobile application development?*

## 5 RESULTS

The following subsections outlines the results related to the research questions related to the adoption of agile practices to develop mobile applications. We adopted the content analysis as a qualitative research technique to identify the challenges and perceived benefits on the adoption of agile methods for developing mobile applications.

### 5.1 Challenges in Mobile Application Development

In mobile application development, apart from adopt agile or a traditional approach, developers face many challenges. Based on our data collection, we identified five main challenges related to the adoption of agile practices in mobile application development. Table 2 shows these challenges.

- **Define UI/UX (User Interface/User Experience Design):** UX was cited as one of the factors that differ developing mobile applications for traditional applications. This is point as a challenge

Table 2: Challenges for mobile application development.

Challenges	Frequency
Define UI/UX	50%
Different users' expectations	30%
Different development platforms	20%
Continuous update	10%
Devices and applications performance	10%

because of the diversity of devices, sensors and features that may be are utilized using a mobile device. UI has also been cited as one of the factors that differ developing mobile applications for traditional applications. It due to the diversity of devices and different sizes and development platforms that can be used to develop applications. Participants explain this challenge.

*I think the main difference is about UI, not for the huge amount of different screen sizes, but the way applications are used on a desktop computer was always using a keyboard and mouse as input. We have a keyboard when using mobile devices, but instead of the mouse we have touch screen, that has numerous other representations to click, not to mention the use of all other sensors available, which makes creating the interface to integrate harmoniously challenging. (Participant B)*

*In my opinion, it's different because you need to think much more in the user experience. Usually the applications are for a general audience, then you should pay attention to all aspects (accessibility, design). (Participant E)*

- **Different Users' Expectations:** the diversity of users and their expectations is identified as a challenge in mobile application development. First, a single application may have millions of users, according to the sense that a lot of users also corresponds to a large diversity of users, with different expectations, demands and devices. Another point raised it is also the question of the speed in which mobile solutions need to be released.

*I think the main difference to develop mobile (applications) over other platforms is the proximity to the user. It is common for a mobile application to be used by millions of people, while a desktop system is different. In my point of view, mobile applications can help change the lives of people in a more direct and fast way, compared to some other systems. The biggest challenge is to promote solutions that really make a difference in people's lives. (Participant J)*

- **Different Development Platforms:** differences between hardware and software platforms have also been identified as one of the differences and challenges in developing applications for mobile devices. It due to the fact that the amount of application program interfaces (APIs) in each of the development platforms, as well as different features and differences in hardware.

*The great diversity of types and capabilities of these devices also creates a challenge for developers, because they need to develop the system in such a way that it is able to run satisfactorily in a wide range of devices. (Participant K)*

- **Continuous Update:** the constant updating of technologies is also cited as one of the main challenges due to frequent updating of development platforms, as well as the frequent launch of devices with different sizes and features. A participant describe it.

*As challenges, I believe the fact that you have to keep up to date because the mobile development is always emerging innovations, new frameworks, new languages. (Participant C)*

- **Devices and Application Performance:** another issue reported by the participants is performance on data access. It happens because of hardware limitations. We can also observe this aspect as an important aspect on the mobile development based on the following answers from the participants.

*It's different, because we have to think of something practical that fits in a relatively small screen and that is attractive. I think the biggest challenge is to be always updated and seek the best performance for the application, or it will become obsolete very quickly. (Participant B)*

## 5.2 Perceived Benefits of Agile Practices for Developing Mobile Applications

Agile development as well mobile application development are research areas with many important aspects to be investigated. Despite of its challenges, we also identified a set of eight benefits of the adoption agile practices for developing mobile applications. Table 3 list the benefits.

- **Improves the Management and Control:** agile process address the inherent problems of traditional development using product demand and delivery, and also control of ongoing projects. Thus,

Table 3: Perceived benefits of agile development for developing mobile applications.

Benefits	Frequency
Improves the management and control	45%
Improves development speed	25%
Continuous improvement	15%
Promotes a life-cycle delivery	15%
Support multiple interactions	10%
Improves communication	10%
Improves performance	5%
Allows transparency	5%

agile processes implement control through frequent inspection and adaptation and support the project management.

*I believe it is extremely important, it enables better organization and control of tasks as better ways to follow the team. (Participant H)*

- **Improves Development Speed:** agile practices helps to attain development velocity. It specially because agile practices focus on short development cycles. Agile development teams tasked to deliver high-value features quickly.

*Agile practices positively influence the mobile development, because they are usually solutions that require immediate and rapid development. With many interactions agile is fundamental because with this the team is able to design and prototype a product with more speed, unlike other methodologies. For example, Waterfall approach validates the implementation only at the end of the cycle. (Participant C)*

- **Continuous Improvement:** agile principles, practices, and methods support continuous improvement. Through constant iterations, iterative planning and review, agile development brings the expected results.

*The use of agile practices helps to make application development safety because it is possible to identify and eliminate failures or unwanted behaviors quickly and accurately. (Participant M)*

- **Promotes a Life-cycle Delivery:** one of the great advantages of agile software development is the wealth of practices, techniques, and strategies that promote a delivery life-cycle. Agile teams will adopt a life-cycle that is the most appropriate for their situation. The delivery life-cycle is goal-driven.

*I believe that the use of agile methods help one mobile team to organize and deliver. Es-*

pecially if the project is very long. This requires collecting metrics during the iterations. (Participant C)

- **Support Multiple Interactions:** the product life-cycle goes from the initial idea for the product, through delivery, to operations and support and often has many iterations of the delivery life-cycle. Multiple iterations promote fast development cycles and incremental improvement of applications. Furthermore, multiple iterations allow teams not only to plan at the iteration level but also to conduct long term release planning (Smite et al., 2010).

*I believe it is fundamental for development, mainly by constant reviews that facilitate troubleshooting and redefinition of the scope of the project (if needed). The various existing iterations on agile methods are extremely important for the application's success. Agile methods facilitate and assist mobile development. (Participant E)*

- **Improves Communication:** agile development in general use a set of values, principles and practices to guide teams in being as agile as possible. It includes the adoption of models to support communication and understanding. Their adoption facilitates communication between the group and make team members more critical.

*It improves the communication and teamwork among team members providing a realistic view about project progress. (Participant R)*

- **Improves Performance:** agile practices can help to improve the project performance in mobile development environments. It because agile practices provide a major performance of developers. Agile teams provide an agile plan with progress updated every day.

*I think that helps a lot in performance improvement. Perhaps even more than other areas of development. It fits very well with mobile development. (Participant A)*

- **Allows Transparency:** it was also raised as a point of clarity and objectivity generated by the use of agile development. Software projects only succeed with effective planning, visibility, and coordination. Agile practices promote a disciplined project management.

*My experience with agile development was great, in my opinion it is essential to use*

*this methodology because it makes the development process more objective and clearer. (Participant B)*

An important aspect to be observed in the use of agile practices. Thus, Figure 1 presents agile practices used by the participants to develop mobile applications during the course.

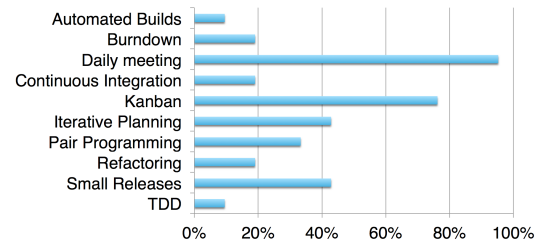


Figure 1: Agile practices used by participants in this study.

The majority of the participants adopt daily scrum meeting practice, because it helps them to keep track of project activities and communication. The second practice more adopted by the participants is Kanban (a system for visualising work do be done, in progress or completed). By the adoption of Kanban participants can see the progress of each activity, what still need to be done, what is in progress and what is completed. Iterative planning was also reported by participant. This practice help to organize the development and deliverables on different interactions and continues improvement. Small releases is also used by participants in order to organize different deliverables in accordance to the iterative planning. Pair programming was also reported as very useful specially when participants need to learn something new or need to work on something critical. Burndown, continuous integration and refactoring were reported by less than 20% of participants. Automated builds and TDD (Test Driven Development) were reported by less than 10% of participants.

## 6 DISCUSSION

Developing mobile applications can be hard due to many reasons. In this study, we found five main challenges. These challenges are faced for both beginners practitioners as well as more experienced developers. We also identified eight benefits of the adoption of agile practices for mobile application development.

The majority of the answers given by interviewees (50%) reported UI/UX as challenge for mobile application development. According to Dalmasso et al. (Dalmasso et al., 2013), most of the developers would like to release apps for major mobile platforms (iOS,

Android) and provide a consistent UI and UX across the platforms. However, developing an app for separate mobile platforms require in-depth knowledge of their SDKs (Software Development Kit). The developer can control all aspects of the user experience, but a mobile application must share common elements of the user interface with other applications and must adhere to externally developed user interface guidelines (Wasserman, 2010). The diversity of mobile platforms, as well as the variety of SDKs and other tools contributes to increase this challenge.

Different users' expectations and different development platforms are reported in 30% and 20% of the answers, respectively. This result shows that the main elements of mobile applications, user and technology, can pose challenges in mobile development. As well as, it poses challenges in teaching and learning mobile software development. We believe that this challenge will increase over the years. It can happen due to the increase number of new users and technologies. A single mobile application can reach millions of users with different devices, age groups, and supported by different platforms.

Continuous update and devices applications performance are reported in 10% of the answers given by interviewees. These challenges have a lower percentage when compared to define UI/UX challenge. However, these challenges are not less important, and in fact mobile applications are becoming more complex and users require high-quality mobile apps (Wasserman, 2010).

We also identified the benefits of the adoption of agile practices for mobile application development. The greatest benefit according to our findings is to improve the management and control. It makes sense, since agile approaches are focused project management (Scharff and Verma, 2010). At the same time, agile practices help to increase the development speed. It is very important in the mobile market since new applications are available every day in the Apps store.

The benefits of agile practices adoption described in this study are not necessarily restricted to the specific type of software development and it can also be extended to other software application domains. On the other hand, we identified challenges in mobile application development domain. A further investigation should be conducted in order to explore the relationship between challenges and achieved benefits.

An unexpected benefit from the adoption of agile practices was presented in terms of students engagement and motivation. We did not report this benefit in Section 5.2. However, it is important to highlight its contribution for teaching and learning mobile ap-

plication development.

Our study is helpful in uncovering the underlying challenges and their implications on existing practice. First, challenges identified enable further research on more detailed activities important to consider while implementing an agile project for mobile application domain. Second, the benefits reported here have been mentioned by the interviewees and identified during the coding process alongside the challenges. Similarly to the challenges, some benefits can be more perceived than others.

## 6.1 Limitations of this Study

Our study was conducted with a limited number of respondents and from the same iOS development course. In addition, our results are drawn the viewpoint of students (development teams). It is also important to notice that part of project participants were attending a training course without previous experience with other approaches or software practices. These features highlight the fact that participants may become comfortable with it, and accepted the environment challenges and its limitations.

However, our results demonstrated that on using agile practices as part of a mobile application development environment are similar to previous literature studies. Our results have also shown that short development cycles and small releases are important features on mobile application development environments. We have found indicatives in our study that agile practices are the best approaches for mobile software development environments.

## 7 FINAL REMARKS

This study explores the adoption of agile practices for mobile application development. In other words, we investigate challenges and the students' experience on the adoption of agile practices. We identified five main challenges in mobile application development and eight benefits of agile practices for developing mobile applications.

Our results show that the main challenge to develop mobile applications is to define UI and UX followed by achieve different users' expectations. Regarding to the benefits, we found improvements on management and control as well as development speed. All teams finished their application projects (apps) delivering more than five different applications covering areas such as games, public transportation, services and productivity. Their apps presented a high

quality and used advanced resources such as data persistence, web services, etc.

Results from our study can be used to support developers, project managers, decision makers, and practitioners in order to choose the software development methodology to develop a mobile application project.

For future work, we will use the findings of this study to design an approach for teaching and learning mobile application development. The adoption of agile practices for mobile application development will be further investigate in order to propose new practices and processes to support software development.

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