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Evaluating Processes to Certify Mobile Applications During Developer Relations Activities

AWDREN FONTÃO[1,2], PEDRO PAES[1], OSWALD EKWOGE[2], RODRIGO PEREIRA DOS SANTOS[3], AND ARILO CLAUDIO DIAS-NETO[2], (Member, IEEE)

[1]Faculty of Computing (FACOM), Federal University of Mato Grosso do Sul (UFMS), Campo Grande 79070-900, Brazil
[2]Institute of Computing (ICOMP), Federal University of Amazonas (UFAM), Manaus 69067-005, Brazil
[3]Department of Applied Informatics (DAI), Federal University of the State of Rio de Janeiro (UNIRIO), Rio de Janeiro 22290-240, Brazil

Corresponding author: Awdren Fontão (awdren.fontao@ufms.br)

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ABSTRACT In a Mobile Software Ecosystem (MSECO), the software organizations have opened up their structures to third-party developers aiming to reach goals to ensure the MSECO is working properly, such as increasing number of users, mobile applications (apps) and developers. Thus, the management organization (keystone) by their Developer Relations (DevRel) teams must restructure its processes to support third-party developers and create ways to attract the development of apps. The development of apps during events planned and conducted by DevRel team (e.g., hackathons or developer conferences) requires an approach that allows developers to achieve the expected performance into the MSECO. However, there is a quality contribution barrier, the App Store, the App Store's criteria do not guarantee that apps certified by these criteria have good performance in number of downloads and positive reviews into the MSECO. Aims: We present an evaluation of a mobile certification approach for the MSECO context, called MSECO-CERT (Mobile Software ECOsystem app CERTification), in terms of mobile application downloads, ratings and changes in developers' attitudes. MSECO-CERT comprises support (MSECO-SUP) and development (MSECO-DEV) processes. We describe two empirical studies: feasibility and observational. MSECO-CERT produced a growth coefficient of downloads (363%) and average user ratings (28%) when compared to an ad hoc approach. We observed that the DevRel practitioners (i.e., developer evangelists) and most of the developers (70%) considered MSECO-SUP and MSECO-DEV processes easy to use. They indicate that they would use both processes in the future. The results indicate that a keystone needs to invest in the analysis of their certification processes considering the ecosystem elements and also create mechanisms that allow monitoring the effect of DevRel activities. Our studies also helped to evolve MSECO-CERT by refining roles, activities and artifacts.

INDEX TERMS Software ecosystem, developer relations, mobile application.

I. INTRODUCTION

An MSECO (Mobile Software ECOsystem) consists of a category of software ecosystem (SECO) that comprises several elements centered on the mobile application. A mobile application is an artifact produced by developer(s) and acquired by users [17], and it represents basic software units being grouped and categorized [18]. From a technical perspective, a mobile application is a software embedded in a mobile device with performance variability and finite energy source [21]. In addition to the mobile applications, there are developers responsible for creating and publishing mobile applications. Mobile applications are consumed (either free or paid) and reviewed by users. In this scenario, a central organization (or keystone) is responsible for the MSECO management and allocates an organization's experts, members of a Developer Relations (DevRel) area known as evangelists to support developers' activities. The mobile

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application store (or app store) has a key role in the success of an MSECO, setting policies for the mobile applications acceptance, i.e. those that will be available to end-users [2]. These elements have distinct responsibilities and they must contribute to the ecosystem so as to properly maintain its structure, balance, and work [1]. It refers to the concept of health. According to Manikas and Hansen [3], ecosystem health is the ability of an ecosystem to survive after any disturbance and remain productive over time.

An MSECO research challenge is to understand processes that support (and foster) mobile applications' production [1], [16]. Additionally, it is important to define processes in order to make the definition and organization of activities related to the ecosystem elements as better as possible. Keystone strategies to assure product quality include certification processes that lets mobile applications get an expected performance regarding downloads and ratings [22]. The certification can be defined as the process of evaluating mobile applications that will bring a positive impact on MSECO health indicators, more specifically the number of downloads and app ratings [14]. Some empirical studies and industrial reports [30] point out that once a mobile application is available to users in stores, it is very difficult to reduce the impact of ''first impression'' by correcting any technical or business issues. Thus, the pre-publication moment – which involves app conception, design and construction – it is very important to the MSECO health. In this scenario, we evaluated a process-based approach to certify mobile applications in the context of MSECO, called MSECO-CERT. This approach consists of three processes: Orchestration (followed by the keystone), Support (followed by evangelists), and Development (followed by developers).

MSECO-CERT was built up from a research methodology based on a set of empirical studies: a systematic mapping [1] to identify activities, recommendations and practices in the MSECO context; a peer review [5] with DevRel experts (e.g. Apple, Google and Microsoft platform managers) in the certification processes in order to evaluate activities, artifacts and roles involved in the MSECO context; and opinion surveys [2], [6] with official evangelists and novice/experienced developers from the main existing MSECO (Android, iOS and Windows) in order to analyze the processes applicability and usefulness. Once MSECO-CERT was developed, we planned empirical studies to evaluate the proposed approach as well as to identify its limitations in order to enable technology transfer to the industrial context [7]. Our paper presents the sequence of empirical studies conducted to evaluate MSECO-CERT, describing their results and how they can support the technology transfer to industrial context. As such, we report the two studies that comprise Shull *et al.*'s methodology [7], conducted with different communities and locales, in the North and South Brazil: (1) the feasibility study conducted to examine whether the MSECO-CERT reaches its promised goals; (2) the observational study performed to analyze the MSECO-CERT adequacy in a real scenario and potential refinement.

The feasibility study was performed with two Windows MSECO evangelists and 30 developers. On the other hand, in the observational study, an evangelist with experience in Android and Windows MSECO trained and supported 10 developers with experience in web development.

II. BACKGROUND

A. MOBILE SOFTWARE ECOSYSTEM

The set of elements surrounding the development of mobile applications as well as their relationships is referred to as Mobile Software Ecosystems (MSECO). An MSECO consists of a cooperative evolution system of mobile applications, developers and users that form complex relationships by creating niches, competing and cooperating, similar to biological ecosystems [8].

In an MSECO there is a reference element to the initial quality of mobile applications, the Mobile Application Store (App Store). This store usually offers quality criteria to be achieved by developers that submit their mobile applications. There are three levels of quality assurance practices identified by Corral *et al.* [23]: development processes, product assurance, and implementation. From this point of view, the mobile application quality assurance is not possible only from the store's criteria but requires health indicators, such as number of downloads and average ratings [1]. There are other essential factors to achieve a healthy ecosystem. One of them is the relationship between developers, users, evangelists and mobile application, because they influence not only the way in which the applications are developed, but also the way the applications are made available to the MSECO users.

Within the basic structure provided by the main MSECOs' keystones, there are strategies to support third-party developers, such as development/testing tools and code templates. In this context, there is a class of internal employees who mediate the relationship between a keystone and third-party developers, member of a Developer Relations (DevRel) area, known as developer evangelists [6]. One of the activities of an evangelist is to plan and execute training sessions about the existing technologies of an MSECO platform to increase the number of well-prepared developers as well as the quality of developers' contributions (apps) based on reuse of platforms' functions [29]. It helps to sustain the MSECO health.

Axelsson and Skolund [14], from a systematic mapping study, discuss that health is related to business and management dimensions. In this context, the ecosystem health can be monitored through a strategic release planning. Another important point is to deal with the cooperation between ecosystem elements including life-cycle processes. Keystones need to support elements in different ways to allow them maintain their health [24], [26]. In their proposed research agenda regarding the organizational processes, Axelsson and Skolund [14] from a business dimension indicate the element certification as a mechanism that can be used from the organizational perspective giving to MSECO elements different access to privileged resources. Only trusted

and certified elements affect the overall experience of the ecosystem, as discussed by Eklund and Bosch [27].

Strategies for automatically certifying elements based on performance can be a direction for future research [1], [16], [28]. In this scenario, the relationship between the elements previously mentioned must be considered during the definition and execution of several processes that surround an MSECO. Therefore, a mobile application certificate shall be verified by specific processes, because the process quality influences the product quality; in this case, the mobile application [22]. In this context, the next section describes a process approach based on mobile application certifications in MSECO..

B. MSECO-CERT

From the analysis of the elements that compose an MSECO and their interactions, it was possible to identify three important processes required by an MSECO to support external contributions and still remains productive. This approach is known as MSECO-CERT (Mobile Software Ecosystem App Certification). Below the processes that comprises MSECO-CERT:

1. Orchestration Process (MSECO-ORQ): arises from the interaction between the keystone and the evangelist, since this process is based on MSECO guidelines for performing support activities;
2. Support Process (MSECO-SUP): defines the workflow that drives the interactions between evangelists and developers, since the evangelist is responsible for monitoring the ecosystem guidelines and production of mobile applications;
3. Development Process (MSECO-DEV): comprises activities related to the mobile application development.

A MSECO-CERT process comprises a set of activities, as a means to structure the workflow related to the elements that are part of the MSECO. For each activity, roles are associated to them in order to help the analysis of interaction between elements. This workflow uses and produces artifacts as part of the activity execution.

A recommendation is associated with an activity and consists of an instruction to execute an activity. In addition, practices were associated with activities and consist of exercises to achieve concrete results regarding the organizational goals. These practices are only associated to those activities carried out before the submission of a mobile application to the store, because that is the point in which the evangelist has influence. As a third step, a pair review [5] with evangelists, developers and keystones' participants (e.g. managers from Apple, Google and Microsoft) in the areas of the three processes was executed in order to evaluate activities, artifacts and roles involved in an MSECO scenario.

The following sections summarize the two processes that compose the MSECO-CERT which are used in the feasibility and observational studies described in this paper. Considering that a modification in the MSECO orchestration is not a fast process and is associated with the strategy of the central organization, we did not evaluate, at this study, the usage of MSECO-ORQ in the experiments, because the flow of activities remains the same in relation to the three major ecosystems (i.e., Android, iOS and Windows) and does not change frequently. The focus was on the evaluation of MSECO-DEV and MSECO-SUP. The MSECO-ORQ was assessed by the impact of the usage of the another MSECO-CERT processes.

1) MSECO-SUP: SUPPORT PROCESS

The goal of this process is to support a relationship between the keystone and third-party developers. MSECO provides an actor from DevRel team responsible for this connection: evangelist [1]. MSECO-SUP comprises 9 activities, 6 artifacts, 9 recommendations, and 44 practices. A summary of the process with activities, recommendations and artifacts is presented in Table 1.

TABLE 1. MSECO-SUP components.

[Activity 1] Prepare sample codes.
Recommendation: codes must attend the MSECO guidelines.
Required artifact: MSECO guidelines.
Produced artifact: sample codes.
[Activity 2] Create posts.
Recommendation: use design standards for app development.
Required artifact: MSECO guidelines.
Produced artifact: technical material.
[Activity 3] Record videos based on material.
Recommendation: the developer must evolve his/her idea in order to prepare marketing material for an app; images and icons must follow standards.
Required artifact: MSECO guidelines, technical material.
Produced artifact: technical material.
[Activity 4] Consolidate support material.
Recommendation: generate a document with the results of the analysis.
Required artifact: technical material.
Produced artifact: support material.
[Activity 5] Prepare action.
Recommendation: images of app screens can be added to the package.
Required artifact: support material and MSECO guidelines.
Produced artifact: action plan.
[Activity 6] Execute action.
Recommendation: developers should be aware of submission rules that can be found in the support material.
Required artifact: action plan.
Produced artifact: action's results.
[Activity 7] Analyze action's results.
Recommendation: developer must monitor mobile applications via e-mails or accessing the Developer hub.
Required artifact: action's results.
Produced artifact: results' report.
[Activity 8] Follow action's participants.
Recommendation: consider users' comments and reviews related to app evolution and release updates in order to add new features.
Required artifact: results' report.
Produced artifact: does not have.
[Activity 9] Update result's report.
Recommendation: share internally and externally for review with those involved in the action.
Required artifact: results' report.
Produced artifact: results' report (updated).

2) MSECO-DEV: DEVELOPMENT PROCESS

The goal of this process is to help developers plan, design and develop mobile applications, during an event (e.g.: developer conference or hackathon) that will be submitted to an application store. To do so, a developer can use artifacts generated in both the orchestration and support processes. So, it can contribute to MSECO productivity and niche creation. MSECO-DEV comprises 8 activities, 7 artifacts, 8 recommendations, and 16 practices. A summary of the process with activities, recommendations, and artifacts is presented in Table 2.

TABLE 2. MSECO-DEV components.

[Activity 1] Define mobile application scope.
Recommendation: consider how hardware and operating system software features (e.g. screen navigation control) can affect app development.
Required artifact: MSECO guidelines, support material and third-party APIs/SDKs documentation.
Produced artifact: mobile application scope.
[Activity 2] Develop mobile application.
Recommendation: use design standards for app development.
Required artifact: support material, app scope and development tool.
Produced artifact: mobile application binary package.
[Activity 3] Prepare mobile application.
Recommendation: a developer must evolve his/her idea in order to prepare marketing material for an app; images and icons must follow standards.
Required artifact: MSECO guidelines and support material.
Produced artifact: marketing package.
[Activity 4] Analyze mobile application (store's quality criteria).
Recommendation: generate a document with the results of the analysis.
Required artifact: mobile application binary e support material.
Produced artifact: binary package reviewed e compliance report.
[Activity 5] Analyze marketing package.
Recommendation: images of app screens can be added to the package.
Required artifact: support material, marketing package and binary package.
Produced artifact: marketing package.
[Activity 6] Submit mobile application.
Recommendation: developers should be aware of submission rules that can be found in the support material.
Required artifact: developer hub, support material, marketing package and binary package.
Produced artifact: submission status.
[Activity 7] Follow approval status.
Recommendation: developer must monitor mobile applications via e-mails or accessing the developer hub (i.e., portal that supports the mobile application management).
Required artifact: developer hub.
Produced artifact: published mobile application e publish status report.
[Activity 8] Follow mobile application into the store.
Recommendation: consider users' comments and reviews related to app evolution and release updates in order to add new features.
Required artifact: developer hub and mobile application store.
Produced artifact: mobile application report.

The next section describes the feasibility study conducted for the evaluation of MSECO-CERT based on MSECO-SUP and MSECO-DEV.

III. FEASIBILITY STUDY

The goal of the feasibility study is to create a body of knowledge about a technological application. The researchers analyze this feasibility study based on whether the MSECO-CERT application is feasible. In other words, if it meets the initial objectives defined to a reasonable extent (effects on MSECO health based on download and evaluation analyses of mobile applications). Moreover, we hope that the constructed body of knowledge provides benefits that allow: (a) technological refinement, and (b) the generation of new hypotheses on the use of the approach to be investigated in further studies [7].

A. STUDY GOAL

The aim of this study is to answer the following research question: "*Is the use of the MSECO-CERT approach to certify mobile applications developed in the MSECO context feasible by analyzing efficiency regarding the number of downloads and ratings of developed applications?*".

The approach was evaluated with evangelists and mobile application developers in a real MSECO context, more specifically, the Windows MSECO with the support of MSECO-DEV and MSECO-SUP processes. The results obtained from feasibility study should help us compare the MSECO-CERT approach in relation to an ad hoc approach (i.e. their own support activities of an evangelist and the development activities performed by a developer).

An ad hoc approach from another evangelist was applied because no other similar approach to MSECO-CERT is available in technical literature to be applied in this study [1], [31]. The ad hoc approach from another evangelist follows basic guidelines indicated by keystone. In order to evaluate the MSECO-CERT approach, the approach was analyzed to verify whether it helps in the evangelization of mobile application developers and in the development of mobile applications that are related to MSECO health indicators, such as downloads and user ratings.

B. QUESTIONS AND METRICS

The research questions (RQs) of this study and the metrics that aim to answer them are as follows:

- (RQ1) What is the efficiency of the MSECO-CERT approach in relation to an ad hoc approach with respect to the number of downloads of mobile applications?
  - Metric: Number of downloads of mobile application developed by participants;
- (RQ2) What is the efficiency of the MSECO-CERT approach in relation to an ad hoc approach with respect to the rating of the published mobile applications?
  - Metric: Average rating of mobile application developed by participants.

There is still an open question in this study, as follows: *Is there any positive or negative change in attitude in the use of the MSECO-CERT approach in relation to an ad hoc approach used by evangelists?*

C. HYPOTHESIS

Two null hypotheses were defined for this study, one for each research question as shown in the following sections.

1) NUMBER OF DOWNLOADS

a: NULL HYPOTHESIS A (H_{0A})

There is no difference in number of mobile application between developers and evangelist developing mobile applications with or without the MSECO-CERT approach.

$$H_{0A} : App_M = App_A$$

b: ALTERNATIVE HYPOTHESIS 1 A (H_{1A})

MSECO-CERT allows the development of the most downloaded mobile applications than those developed with the use of an ad hoc approach.

$$H_{1A} : App_M > App_A$$

c: ALTERNATIVE HYPOTHESIS 2 A (H_{2A})

An ad hoc approach allows the development of mobile applications that are more consumed by users than those developed with the MSECO-CERT approach.

$$H_{2A} : App_A > App_M$$

where:

- App_M = number of mobile application downloads developed with MSECO-CERT approach.
- App_A = number of mobile application downloads developed with an ad hoc approach.

2) AVERAGE RATING OF MOBILE APPLICATIONS

a: NULL HYPOTHESIS B (H_{0B})

There is no difference in average rating of mobile applications between developers and evangelist developing mobile applications with or without the MSECO-CERT approach.

$$H_{0B} : MA_M = MA_A$$

b: ALTERNATIVE HYPOTHESIS 1 B (H_{1B})

MSECO-CERT allows the development of mobile application with higher ratings when compared to those developed with an ad hoc approach.

$$H_{1B} : MA_M > MA_A$$

c: ALTERNATIVE HYPOTHESIS 2 B (H_{2B})

An ad hoc approach allows the development of mobile applications with higher ratings when compared to those developed with the MSECO-CERT approach.

$$H_{2B} : MA_A > MA_M$$

where:

- MA_M = Average rating of mobile applications developed with the MSECO-CERT approach based on data from the Mobile Applications Store;
- MA_A = Average rating of mobile applications developed with an ad hoc approach based on data from the Mobile Applications Store.

3) DEVELOPERS' ATTITUDES

To analyze the difference between positive general attitudes before and after training, using the MSECO-CERT approach, we defined the following hypothesis:

a: NULL HYPOTHESIS ($H0_{Attitude\ MSECO-CERT}$)

There is no difference between pre and post positive general attitudes using the MSECO-CERT approach.

D. STATISTICAL TESTS

The power of statistical tests corresponds to the probability of correctly rejecting the null hypothesis [10]. Participants were divided into two groups (Section 3.5), a control group (those who used the ad hoc approach), and empirical group (those who used MSECO-CERT approach). The samples are considered independent. For the earlier defined hypotheses of this study and those that refer to the analysis of group selections and attitudes, as well as the comparison between unpaired groups, statistical tests were applied (considering two unpaired groups) in the following order:

1. Verify the normal distribution with the test (Shapiro Wilk) [11];
2. If the distribution is normal, the hypothesis test to be applied is the t-student [11]. This test is considered to be paired if the samples are of the same size;
3. If the distribution is not normal, the hypothesis test to be applied is the nonparametric Mann-Whitney.

E. SELECTION OF PARTICIPANTS - EVANGELISTS

Two evangelists that participated in this study are real practitioners from the software industry with high experience in the Windows MSECO. Initially, they answered a questionnaire based on technical profile characterization. Therefore, characterizing the profile of each participant was possible, as shown on Table 3.

TABLE 3. Evangelists' profiles.

Evangelist 1	
Experience	**MSECO**
4 years	*Windows and Nokia (S40, Asha e S60)*
High level of experience in modelling, development and publishing of mobile applications, as well as in the creation of sample code and documentation. He/She has developed mobile applications by himself/herself and he/she is part of a team in the industry.	
Evangelist 2	
Experience	**MSECO**
3 years	*Windows, Nokia (S40, Asha, S60) and Unity (Games)*
High level of experience in modelling, development and publishing of mobile applications, as well as in the creation of sample code and documentation. He/She has developed mobile applications by himself/herself and he/she is part of a team in the industry.	

Evangelist 1 who used the MSECO-CERT approach is a researcher involved in this paper, and Evangelist 2 works as evangelist in the software industry and he/she applied his own approach already used in his/her previous training sessions (ad hoc) following basic guidelines provided by keystone. Their technical profiles are similar.

F. SELECTION OF PARTICIPANTS - DEVELOPERS

Developers who participated in this study were selected from two undergraduate courses (Software Engineering and Information Systems) participants of a collaboration project between industry (Microsoft) and the university (Federal University of Amazonas). Although the feasibility study was carried out in an academic environment, it is still within the real context of evangelism and mobile application development in an MSECO. Organizations responsible for mobile platforms (e.g. Google, Microsoft, Apple and Nokia) usually establish partnerships with institutions for the training sessions of developers. The population size (15+15 per session) is similar to a real training session audience [2]. As the feasibility study was conducted with evangelists, developers also responded to another pre-questionnaire with eight general questions (Q1 to Q8 presented in Table 4) aimed to characterize the experience in the development of mobile applications based on the Likert Scale (i.e. in five points, from I Totally Agree to I Totally Disagree).

TABLE 4. Generic and specific questions.

Question	Description
Q1	I have heard about mobile application development before.
Q2	I understand the importance of using a process for the development of mobile applications.
Q3	Processes for developing mobile applications help in developing a product with quality.
Q4	Processes to support mobile application development can leverage application production and contribute to higher number of downloads.
Q5	The developers should learn about mobile application development processes.
Q6	I believe that the way a mobile application is developed may influence mobile application consumption by users in a mobile application store.
Q7	I understand the importance of designing an application before develop it.
Q8	I understand the importance of evaluating criteria for acceptance of the mobile application store for mobile application development.
SQ1	Marketing activities are important for the dissemination of mobile application within the ecosystem.
SQ2	Test activities assist the quality assurance of mobile application.
SQ3	The use of the store's acceptance criteria during development favored the submission to the mobile application store.
SQ4	Define the idea and the scope of the application helped me in developing mobile applications.
SQ5	Understand user interface patterns helped me in maintaining the mobile application expected identity by users.
SQ6	I understand the examples used during training sessions.
SQ7	My understanding about the development of mobile applications has improved after training sessions.
SQ8	The evangelist performed an approximate work during training sessions.
SQ9	I was engaged during the activities.

The same questions were answered at the end of the training session, in a post-questionnaire, as a way to identify some positive or negative changes in attitude in the groups, or between them. Such questions were included in specific questionnaires (SQ1 to SQ9 – Table 4) related to the understanding of attitudes from both groups regarding idea, scope, development, marketing, and acceptance criteria of the application store. The effect on developers' attitudes related to the interaction among developers and evangelist who executed this training session were evaluated, as well as a developer's self-evaluation of his/her commitment during the training sessions. The next section describes the study execution and the results obtained regarding the hypotheses and research questions.

G. EXECUTION AND ANALYSIS

The feasibility study was carried out online, that is, participants carried out the development of mobile applications at the same time and in a place with the same infrastructure. Initially, the participants read the Informed Consent Form and answered the Pre-Characterization Form in order to identify their profile and experience in mobile application development (it is explained in the next section).

1) DEVELOPERS' DISTRIBUTION

30 developers were divided into two balanced groups, Group 1 and Group 2, taking into account previous knowledge in mobile application development. Regarding knowledge in mobile applications development, the pre-characterization form aided in grouping the participants. All the participants had previous knowledge on mobile application development for the Android MSECO as part of knowledge acquired from an undergraduate discipline.

Thus, the division of groups was based on similar technical. MSECO-CERT approach was applied with Group 1, i.e., the evangelist used the MSECO-SUP process and the developers used the MSECO-DEV process. Group 2 used an ad hoc approach for both the evangelist and developers.

As with traditional training sessions conducted by MSECO organizations [29], the gifts raffled among the developers that published mobile applications during the training sessions were the same for each group, and participants were aware of this: two Lumia's smartphones, which had the Windows MSECO platform.

2) . STUDY'S EXECUTION PROCEDURES

For the training execution on mobile application development for the Windows MSECO, the instructors were evangelists with experience in the Windows platform. The used platform was the Windows 7.5 and Visual Studio 2012. This configuration was supported by the infrastructure provided by the university.

The same training sessions syllabus was used for both groups, offering a basic course on: a) mobile application development concepts; b) development tools; c) development standards; d) user interface; e) groups, methods, and mobile application behavior; f) code debugging; g) mobile application packaging; and h) publication of mobile applications.

The goal of both groups was the development and publication of mobile applications. The course load for the training sessions of each group was 18 hours, organized in one week.

After the training sessions, the evangelists began the developers' follow-up phase (MSECO-SUP process) which lasted for two weeks after training sessions. To do so, chats were created with WhatsApp and Facebook instant messaging tools for Group 1 and Group 2. The follow-up was carried out with the objective of concluding the development of mobile applications and submitting them to the mobile application store (Windows Store). The mobile applications were published and made available to the platform users without the intervention of their developers/evangelists. Real users downloaded the mobile applications.

H. RESULT'S ANALYSIS

In this section, apart from discoursing the difference between number of downloads (**Hypothesis H_{0A}**) and the average of application rating (**Hypothesis H_{0B}**) between groups 1 and 2, data were tabulated and presented, as well as the statistical tests of hypotheses, with the goal of analyzing the results significance. The number of mobile application groups is presented in Table 5 as well as the average number of mobile applications per developers.

TABLE 5. Mobile applications developed (total and average number).

Group	Group 1: MSECO-CERT	Group 2: *ad hoc*
Number of mobile applications	10	5
Average number (by developer)	0.67	0.33

1) NUMBER OF DOWNLOADS

Data from the number of downloads were directly collected from the Developer Hub[1] during a period of 30 days from the publication of each mobile application. This procedure was carried out by both groups. To compare both groups, the (rounded) daily average number of mobile application downloads was calculated. With these values, the daily accumulated average number was generated. Such data are presented on Table 6. In order to evaluate the null hypothesis A (H_{0A}), statistical test procedures were carried out, as indicated in Section D.

The data follow a normal distribution from the *Shapiro-Wilk* normality test. Considering the 95% confidence level ($a = 0,05$), the *t-student* test was used to test the hypothesis. The *p-value* obtained is less than 0.00001, and then the result is significant to $(a = 0,05)$. Therefore, the H_{0A} hypothesis is rejected, that is, the comparison of the number of downloads between both groups is not similar. The alternative hypothesis H_{1A} was confirmed, at same time that we can reject the alternative hypothesis (H_{2A}).

[1]https://developer.microsoft.com/dashboard/apps/overview

TABLE 6. Downloads – daily accumulated average number.

Day	Group 1	Group 2	Day	Group 1	Group 2	Day	Group 1	Group 2
1°	4	2	11°	93	20	21°	181	40
2°	11	5	12°	103	21	22°	188	42
3°	18	6	13°	113	22	23°	196	43
4°	28	8	14°	122	24	24°	207	45
5°	38	9	15°	132	25	25°	214	49
6°	49	10	16°	141	27	26°	221	51
7°	61	13	17°	149	33	27°	230	53
8°	68	14	18°	158	34	28°	241	55
9°	76	16	19°	166	37	29°	252	56
10°	84	18	20°	173	38	30°	267	58

To measure a potential real significance of an intervention effect (i.e., the use of the MSECO-CERT approach), a calculation of the effect size was performed. This is an important complement to the null hypothesis as a test of significance, once the resulting *p-values* of the statistical tests do not provide information about the magnitude or importance of a difference [11]. For the set of data presented for both groups, *Cohen d* test was applied [11]. The value found for d was 1.83, which indicates a very large effect of the use of MSECO-CERT.

Collected data (Table 6) allowed us to generate a data dispersion diagram for both groups, as shown in Figure 1. This was performed with the aim of finding a line that describes the linear correlation between a dependent variable (***accumulated average number of downloads – y axis***) and an independent variable (***days – x axis***). We assume that $x > 0$, since there are no downloads on the day "zero".

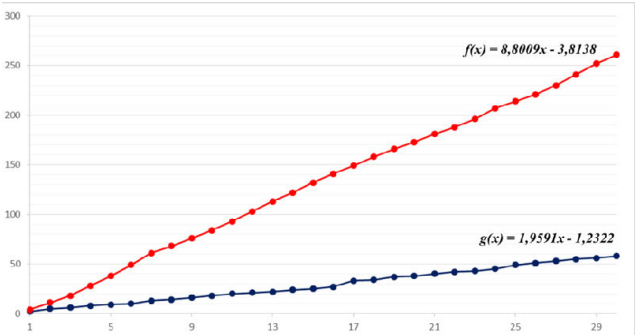

FIGURE 1. Group 1 – f(x) and Group 2 – g(x) functions: accumulated average number of downloads.

After the identification of the line and function that describes the line, the Pearson's correlation coefficient was calculated [15], where the value of the coefficient for groups 1 and 2 was $R = 1$. This indicates that, apart from the variables being positively correlated, the correlation is perfect. Therefore, a comparison between the functions of each group was carried out (Figure 1), where $f(x)$ refers to (Group 1) and $g(x)$ to (Group 2). Since the function may be described as $f(x) = ax + b$, where a is the growth coefficient, we can observe that the growth coefficient of group 1's function

TABLE 7. Ratings: Average, median and standard deviation.

Group	Average of Ratings	Median	Standard Deviation
1	4.5	4.7	0.5
2	3.5	3.5	1.0

(8.8009) is greater than that of group 2 (1.9591). This result confirms a difference between the number of downloads, in which group 1 obtained a greater accumulated mean of downloads.

2) AVERAGE RATING OF MOBILE APPLICATIONS

In order to analyze the mean evaluation for each group, mobile application ratings were taken into account. With this information, the average ratings for each group and the standard deviation were calculated, as described in Table 8. Data allowed us to observe that Group 1 (MSECO-CERT) had a better performance in terms of the users' mobile application ratings, within the interval of 4 to 5 stars.

TABLE 8. Generic question – attitudes before and after using MSECO-CERT.

Question	Pre-Questionnaire				Post-Questionnaire			
	Group 1		*Group 2*		*Group 1*		*Group 2*	
	⊕	⊖	⊕	⊖	⊕	⊖	⊕	⊖
Q1	15 (100%)	0 (0%)	15 (100%)	0 (0%)	15 (100%)	0 (0%)	13 (87%)	2 (13%)
Q2	12 (80%)	3 (20%)	15 (100%)	0 (0%)	15 (100%)	0 (0%)	13 (87%)	2 (13%)
Q3	9 (60%)	6 (40%)	15 (100%)	0 (0%)	15 (100%)	0 (0%)	13 (87%)	2 (13%)
Q4	11 (73%)	4 (27%)	14 (93%)	0 (0%)	15 (100%)	0 (0%)	12 (80%)	2 (13%)
Q5	13 (87%)	2 (13%)	12 (80%)	3 (0%)	15 (100%)	0 (0%)	11 (73%)	4 (27%)
Q6	12 (80%)	3 (20%)	15 (100%)	0 (0%)	15 (100%)	0 (0%)	13 (87%)	1 (7%)
Q7	13 (87%)	2 (13%)	15 (100%)	0 (0%)	15 (100%)	0 (0%)	14 (93%)	1 (7%)
Q8	9 (60%)	3 (20%)	14 (93%)	0 (0%)	14 (93%)	0 (0%)	13 (87%)	0 (0%)

Given that rating data from both groups does not follow a normal distribution, a hypothesis test was carried out ($\mathbf{H_{0B}}$) with the *Mann-Whitney* test, as indicated in Section 3.4. The used confidence level was $a = 0.05$ and with this a value of $p = 0.029$ was found. This result is significant for $a \leq 0.05$, the hypothesis ($\mathbf{H_{0B}}$) is rejected, affirming that there is difference in the average rating of mobile applications of both groups with a 95% confidence level

Group 2's participants developed mobile applications with ratings below 4. However, it is important to understand the variability of mobile applications ratings for each group because only the indicator of ratings is not useful for analysis. Therefore, the *boxplot* diagram was used, as shown in Figure 2. The analysis of the data dispersion (i.e. difference between third and fourth quartiles) from the diagrams

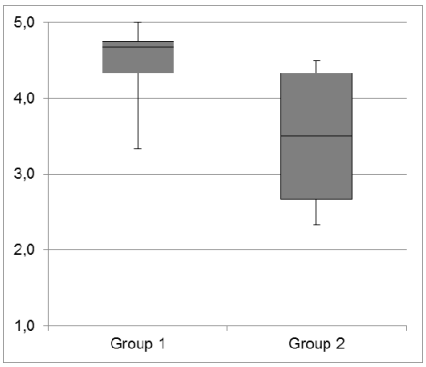

FIGURE 2. Ratings Analysis – Boxplot.

shows that the dispersion of the mobile application rating of Group 1 (0.5) is less than that of Group 2 (1.7). When attention is paid to the rating trends, Group 1 is closer to 4.5.

This average rating is expected from keystones, once they expect the mobile applications to have a mean of at least 4 stars to be considered as good. Meanwhile, the Group 2's ratings divide themselves approximately between 4.3 and 2.5. It helped us to confirm the alternative hypothesis ($\mathbf{H_{1B}}$), i.e. MSECO-CERT allows the development of mobile application with higher ratings when compared to those developed with an *ad hoc* approach, at same time that we can reject the alternative hypothesis ($\mathbf{H_{2B}}$).

3) DEVELOPERS' ATTITUDES

Table 9 shows the attitudes of each developer for the general questions in both the pre-questionnaire and post-questionnaire to answer the open question of this study. Hence, we can carry out an attitude change analysis after using the MSECO-CERT (Group 1) and an *ad hoc* (Group 2) approaches. The generic questions are related to mobile application development, as listed in Table 8.

TABLE 9. Specific questions – attitudes before and after using MSECO-CERT.

Question	Negative Attitude		Positive Attitude	
	C1	C2	C1	C2
SQ1	0 (0%)	3 (20%)	15 (100%)	12 (80%)
SQ2	0 (0%)	7 (47%)	15 (100%)	8 (53%)
SQ3	0 (0%)	5 (33%)	15 (100%)	10 (67%)
SQ4	0 (0%)	7 (47%)	15 (100%)	8 (53%)
SQ5	0 (0%)	1 (47%)	15 (100%)	14 (93%)
SQ6	0 (0%)	1 (7%)	15 (100%)	14 (93%)
SQ7	0 (0%)	5 (33%)	15 (100%)	10 (67%)
SQ8	0 (0%)	5 (33%)	14 (100%)	10 (67%)
SQ9	0 (0%)	6 (40%)	15 (100%)	10 (67%)
Mean	**0**	**4**	**15**	**11**
Standard Deviation	**0**	**2.3**	**0.3**	**2.2**

Regarding the ***Group 1*** attitudes, there was an ***increase in positive attitudes*** and a ***drop in negative attitudes***. Considering the difference from 4 points, we can highlight questions *Q3*, *Q4*, and *Q8*, respectively associated with the use of processes and the impact on development of quality products; processes and the impact on the number of mobile application downloads; and the use of acceptance criteria in mobile application stores as part of development.

In order to analyze the difference between positive generic attitudes before and after training sessions, using the MSECO-CERT approach, we tested the $\mathbf{H0}_{\textbf{Attitude MSECO-CERT}}$ hypothesis:

> **Null Hypothesis ($\mathbf{H0}_{\textbf{Attitude MSECO-CERT}}$):** There is no difference between pre and post positive general attitudes using the MSECO-CERT approach.

We carried out a hypothesis test to verify if there were sufficient statistical results. According to the steps outlined in Section 3.4, the strategy would be to apply the nonparametric *Mann-Whitney* test to evaluate the hypothesis using a 95% confidence level. After that, we obtained at a *p-value* of 0.00452 – a significant value for $\boxed{p \leq 0,05}$ – then the hypothesis $\mathbf{H0}_{\textbf{Attitude MSECO-CERT}}$ was rejected. Therefore, there is a difference between positive general attitudes before and after the use of MSECO-CERT.

When we performed the same analysis for ***Group 2***, even with ***a decrease in positive attitudes*** and ***an increase in negative attitudes***, we could not see any noticeable difference from four developers, who had changed from positive attitude. Therefore, we initially define the following hypothesis to be later tested:

> **Null Hypothesis ($\mathbf{H0}_{\textbf{Attitude } \textit{ad hoc}}$)**: There is no difference between pre and post positive attitudes using an *ad hoc* approach.

The nonparametric *Mann-Whitney* test was applied following the same procedure of the previous test and considering a 95% confidence level. A *p-value* of 0.01174 was obtained – a significant value for $\boxed{p \leq 0,05}$. Therefore, the null hypothesis is rejected.

In **Group 2**, at least four developers believe that the mobile application development process should not be taught by developers, and at least two developers did not understand the importance of using processes for product quality and that it could help in the production of mobile applications that generate good download numbers. A comparison between the attitudes related to the post-questionnaire of groups 1 and 2 was carried out. In order to verify the difference between the positive general attitudes of both groups, the following hypothesis was defined:

> **Null Hypothesis ($\mathbf{H0}_{\textbf{General Attitude}}$)**: There is no difference between the positive attitudes in the posttraining general questions of groups 1 and 2.

Following the previous procedure, the non-parametric *Mann-Whitney* test was applied, where a 0.0027 *p-value* was obtained, which is significant taking into account a 95% confidence level ($\boxed{p \leq 0,05}$). Therefore, the null hypothesis is rejected. Thus, there is a statistical difference between the positive attitudes of Groups 1 and 2 related to the post-training sessions general questions.

Analyzing the data to evaluate the MSECO-CERT approach, it can be observed that, at a 95% confidence level, the use of the MSECO-CERT approach influences attitude changes in relation to the generic questions when compared to an *ad hoc* approach. After analyzing data presented in Table 9, a positive attitude growth for the group that used the MSECO-CERT approach can be observed when compared with the group that used an *ad hoc* approach.

In Table 9, the attitudes of each group for the specific questions that were included in the Post-Questionnaire are tabulated. Therefore, we carried out an analysis of attitude change after using MSECO-CERT (Group 1) and an *ad hoc* (Group 2) approaches. The specific questions are related to idea, scope, development, marketing, and acceptance criteria.

In order to verify the difference among specific positive attitudes of both groups, the following hypothesis was defined:

> **Null Hypothesis ($\mathbf{H0}_{\textbf{Specifc Attitudes}}$)**: There is no difference between the positive attitudes on the posttraining specific questions of groups 1 and 2.

The nonparametric *Mann-Whitney* test was used in the hypothesis test with a 95% confidence level ($\alpha = 0.05$). The *p-value* obtained was 0.00058, which is significant for $\boxed{p \leq 0,05}$. Thus, the null hypothesis was rejected and a statistical difference between the groups was identified, indicating a greater positive attitude among the developers that used MSECO-CERT.

I. REFINEMENTS

Table 10 and Table 11 present the refining points taken into account from the feasibility study, respectively, for the MSECO-DEV and MSECO-SUP processes.

From the use of spreadsheets, it was possible to see that the construction of a presentation of MSECO-DEV and MSECO-SUP processes would be necessary from a support material (e.g., slides). The next section describes the threats to validity of this study, and how they were handled throughout its planning and execution.

TABLE 10. MSECO-DEV: actions for refinement.

Scope	Correction Point	Comment
Practices	General	Put practices in sequence, because developers tend to follow a sequence when using practices.
Activity	Activity 2 (Sequence)	Marketing activity can be moved to the end. Preparation of user experience artifacts could be made in the context of this activity.
Activity	General	Terms has no prior conceptualization. It is necessary to improve the description or create a glossary.

TABLE 11. MSECO-SUP: actions for refinement.

Artifact	General	Provide a package with artifacts' templates.
Activity	[Activity 6] Description	Focus on monitoring the developers' community and on the establishment of interaction with developers, so developers feel motivated to continue the development of mobile applications.
Activity	[Activity 5] Description	It is important to emphasize the preparation of technical material preparation for an action.
Activity	[Activity 6] Description	Align practice and theory for better support the developers' learning regarding concepts and content.
Practice	[Activity 6] Practice Adjustment	Be kind with the participants. In the group 2, one participant said: "*It is important that the instructor wait for some participants who are developing applications slowly*".
Practice	Suggestion	Comment of a Group 2 participant: "*I missed greater interactivity and collaboration between students and the instructor*".

J. THREATS TO VALIDITY

1) INTERNAL VALIDITY

a: INSTRUMENTATION

appropriate instruments were used for both groups, from the questionnaires that went through a review process and submitted to a pilot, to the same development tool (Visual Studio) and common access to the Microsoft's keystone. Both groups used the same platform (Windows 7.5).

b: SELECTION

participants (evangelists and developers) were not randomly selected; technical and psychological profiles were taken into consideration. Groups were equally divided in both the quantitative (one evangelist for each group of 15 developers) and qualitative (similar technical profiles) aspects.

c: MATURATION

in order to eliminate developers' discouragement during the training sessions, developers were informed that there would be a raffle among those who published their mobile applications. The same training syllabus was used and the same goal was defined – publication of mobile applications – to avoid differences in the capacity of both groups.

d: CONTAMINATION

participants of both groups as well as evangelists were instructed to avoid any communication during development, publication and follow up until the training/follow up was considered concluded.

e: COMPETITIVE BEHAVIOR

to reduce competition among developers of both groups, awards, prizes, award rules and goals were equally made available to both groups, with the same control being accomplished by the evangelist of each group.

f: SUBJECT's EFFECT OF EXPECTATION

to reduce this threat information about goals and awards was communicated to the two groups, expectations might be more associated with development achievement, previous publication and award, rather than with positive results of the experiment. Moreover, the participants were not individually evaluated, although both groups in turn were given the same conditions as mentioned in ''Competitive Behavior''.

g: EXPERIMENTER's EFFECT OF EXPECTATION

the evangelist also responsible for this research faithfully followed the MSECO-SUP process in order to not impact on the subject or on the activities carried out by developers.

2) EXTERNAL VALIDITY

a: PARTICIPANTS

participants with good relationship with the population of evangelists and developers, or who reflected the population behavior were selected.

b: TIME

the given time for planning the training sessions was the same for each evangelist (1 month, before the training session), the same training session load (18 hours) for each group,

and the follow up phase had the same duration (two weeks after training sessions) for each group.

c: EXPERIMENT CONFIGURATION

although the training sessions were carried out in an academic environment, this scenario is the same used by MSECO organizations, which characterizes a real environment: infrastructure, tools, and evangelists (for each group)

3) CONSTRUCTO VALIDITY

a: EXPERIMENT PROJECT

the processes that compose the MSECO-CERT approach were developed based on a conception phase: systematic mapping, peer review, and survey. An *ad hoc* approach was used because no approach was found within the MSECO context that could be compared during the conception phase.

b: HUMAN FACTORS (OR SOCIAL)

participants were not involved in other experiments during the realization of this feasibility study. The participants also participated spontaneously in order to acquire knowledge regarding mobile application development and the results were not used as evaluation during the undergraduate course.

4) CONCLUSION VALIDITY

a: ANALYSIS AND STATISTICAL INTERPRETATION OF RESULTS

steps required for the correct statistical test applicability and analysis were carried out as follows: verification of normality, sample size, and appropriate statistical test (Section 3.4).

b: RELIABILITY MEASURES

a potential threat to this study would be the comparison between the total number of downloads for each group. So, we used the daily accumulated average number of downloads and carried out a comparison between the functions generated for each group, where the X-axis represents each one of the 30 days of measurement, and the Y-axis the accumulated mean. Similarly, for mobile application ratings, we compared the average rating of each group. Data were obtained directly from mobile application store reports without interference of the researchers.

c: RELIABILITY OF TREATMENT IMPLEMENTATION

regarding the treatment application it is not being similar between the different study participants, MSECO-DEV contains activities that can be followed during development, publication and follow up of a mobile application. These steps are inserted within the training sessions that the developers participate, which is part of MSECO-SUP.

Even with viable results and confirmation of the applicability of the approach, it is necessary to refine the way to present the approach, the sequence of practices and the description of activities, as well as providing a set of artifacts necessary for the use of the approach. Considering the next steps of the methodology proposed by Shull *et al.* [7], we conducted an observational study to evaluate the practical application of the approach in the scenario where other developers and evangelists would be involved.

IV. OBSERVATIONAL STUDY

An observational study was conducted in the environment where the practical application of the approach could be observed. In this section, we present the planning, execution and results of the use of MSECO-CERT in a real scenario of MSECO. From this study, it is possible to collect data on how it is applied and whether participants would use it again in their activities. Therefore, it is possible to obtain information about possible difficulties that the participants may present [20].

A. STUDY GOAL

Analyze the application of the MSECO-CERT approach with the purpose of evaluating its adequacy in a real context from the perspective of developers and evangelists in the context of engaging and training mobile application developers in achieving organizational goals of an MSECO.

In this observational study, an official evangelist was sought to carry out the training sessions with developers using the MSECO-CERT approach as a way to insert the use of the approach in a real industrial scenario. This study did not aim to compare with the use of another approach, but to obtain information about the difficulties of participants with the use of MSECO-CERT.

This study was conducted in the Windows MSECO and the platform used was the Universal Windows Platform (UWP); in the feasibility study, the platform was Windows 7.5. We decided to choose a different platform to analyze the adequacy of the approach in a scenario in which it is very common to upgrade platforms. Regarding hours of training session, a period of 20 hours in one week (4 hours per day) was used.

B. QUESTIONS AND METRICS

The purpose of this study was to answer the question: "*Does the MSECO-CERT approach fit the real context for evangelism and mobile application development?*". From this study, it was observed how MSECO-CERT behaves within a real training sessions scenario of third-party developers who produce mobile applications with the support of an evangelist.

C. SELECTION OF PARTICIPANTS

Ten developers participated in this study. They have knowledge of the platform language (C#) for the development of desktop and web applications. 8 (80%) developers have never developed a mobile application and 2 (20%) have developed mobile applications individually. All of them have experience in the Windows ecosystem and/or Windows (Microsoft) and one operates in the Android ecosystem (Google). However, to participate in the study, the developers had to:

- Express interest in participating in the study, agreeing to the Informed Consent Form (ICF) and filling in the Characterization Form to allow us identifying the degree of experience of each developer;
- Answer the generic questions presented in Table 4.

The evangelist participated in two meetings with the researchers of this work to avoid any doubts about the use of both MSECO-SUP and MSECO-DEV. The evangelist is also a leader of the Microsoft developer community for Windows and Google developer community for Android, this characterization is described in Table 12.

TABLE 12. Evangelist profile – observational study.

Evangelist		
Experience	**Psychological Profile**	**MSECO**
3 year	*ENFP*	*Windows and Android*
Regarding the experience with mobile applications		
High level of experience in designing, developing and publishing mobile applications, as well as creating sample codes and documentation. He/she has participated in several projects in the software industry.		
Regarding the experience with evangelism		
Evangelism from developer communities (students and universities), from partners (companies, startups and other third-party developers) and community coordination of developers. He/she has participated in several related projects in the software industry.		

The psychological profile differs from evangelists in the feasibility study. In the observational study the evangelist has NF temperament: an idealist psychological profile that is abstract in speech and cooperative in pursuing their goals. His/her best developed intelligence role is mentoring.

D. STUDY'S EXECUTION AND RESULT ANALYSIS

The **execution** of the training sessions followed the same syllabus mentioned in the feasibility study. Participants initially responded to the ICF, characterization form, and the pre-questionnaire with general questions in order to identify the profile of participants and capture general attitudes. The evangelist followed the MSECO-SUP process while the developers followed the MSECO-DEV process.

The workload of 20 hours corresponded only to the execution of the training sessions. The used tool was *Visual Studio Community 2015*, since the platform was the UWP. The group was aware of the sweepstakes among developers who published mobile applications: two Lumia handsets with Windows MSECO's platform.

After completing the training sessions, each participant received a developer account that allows the submission of mobile applications to the Microsoft mobile application store. Then the **follow-up of the developers** was initiated and two hours were established to ask questions with the presence of the evangelist after three days from the end of the training sessions. The follow-up was still performed using tools such as e-mail, Skype and WhatsApp for two weeks after training sessions. Participants also answered a post-questionnaire as a way to understand the change in attitudes and to identify attitudes based on specific questions.

TABLE 13. Developers' attitudes before and after using MSECO-CERT.

Question	Attitude – Before		Attitude - After	
	Positive	Negative	Positive	Negative
Q1	9	1	10	0
Q2	9	0	10	0
Q3	10	0	10	0
Q4	9	0	10	0
Q5	9	0	10	0
Q6	8	0	8	0
Q7	8	0	10	0
Q8	7	0	10	0

1) QUANTITATIVE ANALYSIS

In order to analyze the difference between the positive general attitudes before and after training sessions with the use of MSECO-CERT approach (Table 13), we consider the following hypothesis:

> **Null Hypothesis** ($\mathbf{H0_{Observation\ MSECO-CERT}}$): There is no difference between the general positive attitudes before and after use of the MSECO-CERT approach.

We performed the hypothesis test following the steps indicated in Section 3.4. *Mann-Whitney* nonparametric test was applied using a 95% confidence level. The result was a p-value of 0.02, that is a significant value for $p \leq 0.05$. Thus, the hypothesis ($\mathbf{H0_{Observation\ MSECO-CERT}}$) was rejected and there is a difference between the general positive attitudes before and after the use of the MSECO-CERT approach.

We observed that questions Q1, Q7 and Q8 are related to the development of mobile applications, the importance of designing a mobile application and the use of store acceptance criteria during the mobile application development. Regarding Q6, there was no change in attitudes – two developers had no opinion whether the way a mobile application is developed can influence users' consumption trend in an app store.

Regarding the specific questions, all developers had positive attitudes towards the use of activities, recommendations and practices for the development of mobile applications. They had positive attitudes regarding the use of marketing, testing, definition of scope, and interface standards. When reviewing training session issues, all developers indicated positive attitudes about the used examples, improved knowledge, evangelist's teaching, and self-engagement during the development of the mobile application.

2) QUALITATIVE ANALYSIS

The evangelist was asked about the degree of difficulty of using the MSECO-SUP process for the evangelism of mobile application developers in the context of MSECO. He/she rated the use of MSECO-SUP as easy to apply and commented: "*Easy to use because it is well written, because it*

is easy to understand, makes the mobile application development process more organized and establishes a methodology throughout the work. At first I felt a little difficult to follow, but it is a matter of custom, we always do anyway''.

When asked how MSECO-SUP assisted him in evangelism activities to support development, publication and monitoring of mobile applications, the evangelist gave the following feedback: ''*Positively. MSECO-SUP assisted me in the evangelism of developers who performed activities of developing, publishing and tracking a mobile application. Maybe I would not have gotten the same result if I had not used it*''.

The developers also rated the degree of difficulty of applying the MSECO-DEV process for the development of mobile applications. Seven (70%) considered it easy while 3 (30%) found difficult to use. These three developers before the training sessions had no contact with mobile application development and are within the set of eight developers we mentioned in Section 4.3.

However, when developers were asked how MSECO-DEV assisted in the development, publication and monitoring of its mobile application, all of them (100%) responded positively, MSECO-DEV helped in development, publication and monitoring of the mobile application. Maybe, they would not have gotten the same result if they had not used it. Finally, all developers share the feeling that they would use MSECO-DEV to develop their future mobile applications.

With this study, it was possible to observe that the evangelist and most of the developers (70%) considered it easy to use the respective processes (MSECO-SUP and MSECO-DEV), even indicating that they would use them in the future. The change of platform, the use of MSECO-CERT by other evangelist/developers with a different technical/psychological profile and another training session were factors that make this study different from the feasibility study. It allowed us to analyze the adequacy of the approach in the real scenario of evangelism for the training sessions of new mobile application developers.

E. THREATS TO VALIDITY

1) INTERNAL VALIDITY

a: INSTRUMENTATION

the appropriate instruments were used: the questionnaires that had already been used in the feasibility study, the development tool (Visual Studio) and common access to the Microsoft Developer Center. The measurement of the results of questionnaires was done by counting the answers.

b: SELECTION

As mentioned in the Section 4.1, participants (evangelists and developers) were not randomly selected.

c: COMPETITIVE BEHAVIOR

As a way to reduce competition among developers, awards, rules for awards and goals were made available for both groups.

d: EFFECT OF THE EXPERIMENTER's EXPECTATION

To reduce the effect of researcher's expectations on the subject or activities performed by him/hers, the researcher used MSECO-CERT as a way of preparing the evangelist through training meetings.

2) EXTERNAL VALIDITY

a: PARTICIPANTS

Participants were selected and this choice relates to or reflects the behavior of the population of developers and evangelists as mentioned in planning of the observational study.

b: CONFIGURATION OF THE EXPERIMENT

the observational study was carried out in the real scenario and with the official tools, besides focusing on the current MSECO platform Windows (Windows Universal Platform).

3) CONSTRUCTO VALIDITY

a: EXPERIMENT DESIGN

The processes that compose the MSECO-CERT approach were developed based on a conception phase: systematic mapping, peer review, and surveys. After this, a feasibility study was carried out to support the refinement of MSECO-CERT before using it in the observational study.

b: HUMAN (OR SOCIAL) FACTORS

Participants were not involved in other experiments during the observational study. Subjects also participated spontaneously as a way to gain knowledge regarding mobile application development.

4) CONCLUSION VALIDITY

a: STATISTICAL ANALYSIS AND INTERPRETATION OF THE RESULT

required steps were taken for the correct applicability of statistical tests and analysis: normality check and appropriate statistical test.

b: RELIABILITY OF THE IMPLEMENTATION OF TREATMENTS

MSECO-DEV contains activities that can be followed during the development, publication and monitoring of a mobile application.

V. CONCLUSION AND FUTURE WORK

In an MSECO, keystones should create mechanisms to ensure that their ecosystems remains healthy to encourage the niche creation, supporting market variations and new users and developers. To have control over the health analysis, a keystone use to adopt health metrics such as: number of downloads and average rating of mobile applications by users in the mobile application store. The evangelist can help the developer to contribute to the positive impact of these metrics, which can positively affect the MSECO health.

This paper described the evaluation of a process-based approach to help mobile application certification in

MSECO known as MSECO-CERT. With the feasibility study, it was possible to analyze if MSECO-CERT produces feasible results in comparison to an *ad hoc* approach applied by an evangelist. Therefore, the impact on such indicators was studied. After comparing the results, it was possible to observe a difference between the approaches: a positive effect on the number of downloads and ratings was observed when MSECO-CERT was used. The MSECO-CERT approach produced better download and rating results, however, there was difficulty in using the artifacts created and used by the processes that compose the approach. The following refinements were carried out: 1) Provide a package with artifacts' templates; 2) Focus on monitoring and interaction among developers and evangelists as a way to engage developers in mobile application development; 3) Align practice and theory for better understanding of concepts and content for developers; and 4) Be nice to the participant. In the group 2 (*ad hoc* approach from another evangelist), one participant said: "*It is important that the evangelist wait for some participants who are developing applications slowly*".

In order to evaluate the suitability of the approach with another evangelist and in another community of developers, an observation study was performed. The study aimed to understand the attitudes and use of processes by the evangelist and developers. In this study, participants, evangelist and developers confirmed that the use of the approach helped them positively and that they might not achieve the same results if they had not used it. Participants also stated that they would use the approach to their upcoming activities (evangelism and mobile application development).

The limitations of this research are related to the type of MSECO, evangelist profiles, and community of developers, as follows: 1) the studies were conducted only on the Windows MSECO, so further studies in other MSECO are necessary; 2) the participating evangelists are employees of the Windows MSECO and one is an official Android MSECO evangelist, but it is still necessary to evaluate the use of the approach with different levels of technical profile as well as psychological temperament (although the basic technical profile of an evangelist in the three major MSECO is similar); and 3) the sample of participant developers is representative, but it is important to conduct studies with start-ups and more experienced developers in the context of mobile application development.

This research field is evolving, but still lacks analytical models, industrial studies and study protocols, as concluded by Manikas [16]. Our study helped to identify the need of refining the training session format, to perform an adjustment in sequence of practices/activities proposed to support certification in MSECO, and to provide a set of artifacts. We also observed that MSECO-CERT could guide developers in the interaction with the evangelist and within the MSECO community. Practices related to the follow-up activity of MSECO-SUP were important to the process execution in order to achieve concrete results: the publication of certified mobile mobile applications, the increase of developers' engagement, and the improvement of MSECO health indicators. It is important to identify and study the factors that may affect training sessions performed by evangelists. As an ongoing study, we are investigating how to govern developers in MSECO towards the development of an approach composed of strategies focused on developer experience from technical, social, and business dimensions as a way to improve the attraction and engagement of developers in an MSECO.

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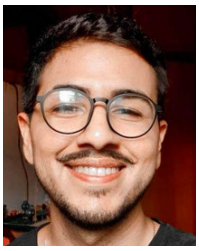
AWDREN FONTÃO received the Ph.D. degree in informatics from the Institute of Computing, Federal University of Amazonas. He is currently an Associate Professor with the Faculty of Computing, Federal University of Mato Grosso do Sul (UFMS). His research interests include developer relations, developer experience, software ecosystem, and software engineering.



PEDRO PAES is currently pursuing the bachelor's degree in software engineering with the Department of Computing, Federal University of Mato Grosso do Sul (UFMS). His research interests include data science, web development, and software architecture.

OSWALD EKWOGE received the master's degree in software engineering from the Federal University of Amazonas with focus on software testing processes and mobile software ecosystems. He is currently an Embedded Software Engineer with the SIDIA Institute of Science and Technology, where he develops embedded software for Samsung mobile devices for Latin American mobile phone operators.

RODRIGO PEREIRA DOS SANTOS received the Ph.D. degree in computer science from the Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering, Federal University of Rio de Janeiro (UFRJ). He is currently an Associate Professor with the Department of Applied Informatics, Federal University of the State of Rio de Janeiro (UNIRIO). His research interests include complex systems engineering (specially software ecosystems and systems-of-systems) and software engineering education.

ARILO CLAUDIO DIAS-NETO (Member, IEEE) is currently an Associate Professor with the Institute of Computing, Federal University of Amazonas. He also leads the University's Experimentation and Testing on Software Engineering Group and participates in industry research and development projects. His research interests include software testing and ecosystems (with focus on mobile applications).