
Technical Report on a Taxonomy of Effort Predictors for Mobile Application Projects

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ABSTRACT

This technical report provides additional information on the results of the taxonomy studies of mobile application project predictors as those resulting from the qualitative study and systematic literature mapping as well as the classification of 108 effort predictors according to the taxonomy categories of effort predictors.

1. The Mobile Application Effort Predictors from the Qualitative Study

Factors affecting effort estimation for mobile application projects in mobile application development companies were identified through qualitative research. These factors were raised through the knowledge gained from the effort estimation of eight mobile application specialists. We used semi-structured interviews and procedures based on Grounded Theory (Strauss and Corbin, 1998).

The identified factors were grouped into 2 different categories (size metrics and cost factors). The category of cost factors has eight subcategories, to facilitate the understanding of the phenomenon being investigated. These subcategories are: Product - Mobile Device, Product - Mobile Application, Client, Company, Development Team, Project - Mobile Application Project, Project - Development Factors, Project - How to Estimate. Table 2 presents the factors that affect the effort estimation for mobile application projects. References P1 to EP8 are detailed in Table 1.

Table 1: Experiences of Respondents in the Qualitative Study

Specialists	Years of Experience
P1	1 year
P6	3 years
P2, P3, P4, P5	5 years
P7, P8	10 years

Table 2: The mobile application effort predictors from the qualitative study

Category	Subcategory	Factor	Description	References
Size Metrics	-	Amount of data	Amount of data required to maintain the Application.	P1, P3, P4
		Number of Requirements	Number of Project requirements	P7
		User Stories	Whether or not you use User Stories to estimate the project	P2, P6
		Screens	Indicates quantity or evaluates each screen sketch as easy, medium or complex.	P1, P3
		Level of Project Documentation	It does not have, it has little detail, it has more detail	P2, P8
		User Interface (UI) document	Whether or not to use the User Interface (UI) Document to estimate the project	P8
		User Experience (UX) document	Whether or not to use the User Experience (UX) Document to estimate the project	P8
Cost Factors	Product:	Mobile Device	The types of connectivity such	P1

Category	Subcategory	Factor	Description	References
	Mobile Device	Connectivity Type	as 3G and Wifi interfere in the preparation of the infrastructure.	
		Mobile Device Operating System	Consider Operating System version and operating system: Android and IOS.	P1, P6, P7, P8
		Mobile Device Screen Size	Which mobile devices are used that can vary the screen size on which the application will run.	P2, P6
		Mobile Device Energy Limitation	Depending on the application types, there is a concern in limiting the device's energy. It consists in the existence or not of this preoccupation.	P1, P3, P4
		Call Interruptions	It consists in the existence or not of this preoccupation in the interruption of calls.	P2, P3
	Product: Mobile Device	Application Presentation Mode	Whether or not there is a differential treatment for a horizontal or vertical screen of the mobile device.	P1, P6, P7, P8
		Targets (Number of Devices on which the application needs to run)	It consists of the number of devices on which the application will run.	P2, P6, P7
		Graphic Interface Complexity Level	There are applications that demand animations, different effects, and have usability concerns. Therefore, the GUI complexity can vary from low, medium to high.	P4, P5
		Integration with Social Networks	Whether or not the application has integration with social networks.	P3, P4, P5
		Request for Internet	If it is a client-server application, the very request that expects a return, can be successful or a failure. Thus, one has to be careful to estimate the alternative paths when it is a client server application and have to think about the responses obtained from the server and also what are the possible responses to be obtained from the server.	P5
		Type of Communication with Server	This communication with server could be Json or XML.	P4, P5
		Dependency with another system	Whether or not a dependency exists with another client system or another API.	P5
	Client	Client Competence Level	It involves knowing the business and how to transmit information.	P1, P2, P4, P6, P8
		Level of Communication with Client	It involves the communication of those responsible for the project with the client that can vary from low, medium to high	P1, P2, P3, P6

Category	Subcategory	Factor	Description	References
			communication.	
		Level of Client Participation	If the customer validates the project specifications, if the client is aware of the project risks, if the customer participates in the product design meeting, these are examples of participation. Participation may vary from low, medium to high.	P1, P2, P3, P4, P5, P6, P7, P8
		Customer autonomy in decision making	Whether or not the client has the autonomy to make a decision on the project.	P7
	Company	Company's Internet Availability Level	It consists of the level of stability/availability of the company's Internet access that can vary from never stable, sometimes stable to stable.	P3, P7
		Level of Availability of Test Devices	Whether or not the devices are available to test the application.	P7
		Level of Company's Tooling Infrastructure	Availability of workspace and tooling that may vary from always available, rarely, sometimes to never.	P8
		Availability of the Infrastructure to speak with the Client	Whether or not there is an infrastructure to talk to the customer	P6, P8
	Development Team	Level of Experience with Technology	The level of experience with the technology that the project needs can vary from none, low, medium to high.	P1, P2, P3, P4, P5, P6, P7, P8
		Knowledge of the Problem	Whether or not the team has knowledge of the client's problem.	P2
		Level of Experience in Development in Previous Projects	The level of development experience in previous projects can vary from none, low, medium to high.	P1, P2, P3, P5, P7
		Level of Team Communication	The level of communication may vary from low, medium to high.	P2
		Level of Knowledge of Team Competence	When the competence of the team participating in the project is known, varying from low, medium to high.	P1, P2
		Level of Team Engagement	It involves the behavior and focus of those involved in the project, that can vary in low, medium to high level of engagement with the project.	P2, P4, P6
		Number of Dedicated Hours of each Person to the Project	It consists of the number of hours spent by each person on the project.	P4
		Number of People Working on the Project	It consists of the number of people working on the project.	P2, P4, P6
		Team Learning Curve	It consists of the time it takes for the team to learn some	P1, P6

Category	Subcategory	Factor	Description	References
			resource, project context or technology needed for the project.	
	Project: Mobile Application Project	Level of Application Context Complexity	If the application needs that the context in which the application will be inserted be studied. Example: stock exchange and banks. This level of complexity can range from low, medium, to high.	P2
		Project Confidentiality Level	If the project requires a confidentiality that can vary from low, medium to high.	P4
		Changes	Whether there is a control of the changes that are made in the project.	P6
		Risks	Whether or not the project is clear of existing risks.	P2
		Project Migration	Whether or not the project is prepared for a possible tool migration.	P1
		Scope Size	Varies by size metrics.	P2, P6, P7
		Scope Type	Whether the scope is open (not defined requirements) or closed (all requirements are defined).	P6
	Project: Development Factors	Flexibility of the Development Methodology	Whether or not there is Flexibility in Development Methodology.	P4
		Task Dependency	Whether or not there is any task dependent on another task.	P5
		Client APIs	Whether or not a Client API is used.	P4
		Level of Requirements Stability	It consists of determining the degree to which the requirements are stable. It can range from low, medium to high stability.	P1, P7
		Level of Requirements Definition	The degree of requirements definition may vary from low (requirements are not defined), medium (a part of requirements is defined) to high (all requirements are defined).	P5
		Variation of ways to perform the same functionality	Whether or not there is a variation of ways to perform the same functionality. Example: the form of payment that can be by ticket, credit card or PayPal.	P4
		Project Premise	Whether the project premises are carried out or not.	P8
	Project: How to Estimate	Identification of MVPs	Whether or not the Minimum Viable Product is identified for the customer.	P7, P8
		Identification of Personas	Whether or not the Personas are identified.	P7
		Product Vision Identification	Whether or not the product vision is identified.	P7

Category	Subcategory	Factor	Description	References
		Product Design Techniques	Whether or not product design techniques are used.	P7

2. Mobile Application Effort Predictors from Systematic Mapping

In this systematic mapping, the publications referring to predictive factors of mobile application project effort were analyzed. From an initial set of 487 publications, 18 publications were selected, resulting in 93 predictors of effort. Table 4 shows the predictors of mobile application effort from systematic mapping. References EP1 to EP3 are detailed in Table 3.

Table 3: Code with Legend of the Systematic Literature Mapping References

Code	References
EP01	Francese et al. (2015)
EP02	De Souza e Aquino (2014) (A)(B)(C)(D)(F)
EP03	Nitze et al. (2014)
EP04	Heeringen e Gorb (2014)
EP05	Pocatilu e Ventrici (2009) (A)
EP06	Pocatilu e Ventrici (2009) (B)
EP07	Huijgens et al. (2014)
EP08	Dombroviak e Ramnath (2007)
EP09	Keränen e Abrahamsson (2005)
EP11	D'Avanzo et al. (2015)
EP12	Ferrucci et al. (2015) (A)
EP13	Ferrucci et al. (2015) (B)
EP14	Abdullah et al. (2013)
EP15	Abdullah et al. (2014)

Table 4: Predictors of mobile application effort from systematic mapping

Metrics	Category	Factor	Description	Reference
Size Metrics	Tamanho			
	Requirements and Models	Number of Functional Requirements	Number of project requirements	EP1
		Number of Actors in the Use Case	Total number of Actors in the project use case can be descriptive or diagram	EP1
		Number of Use Cases	Total number of Use Cases can be descriptive or diagram	EP1
		Number of Classes	Total number of Classes of the project, can be descriptive or diagram	EP1
		Number of Sequence Diagrams	Total number of Sequence Diagrams of the project.	EP1
	Source Code	Number of Classes	Total number of Classes contained in the mobile application source code	EP1
		Number of Files	Total number of project files	EP1
Number of Methods (Including Inherited)		Total number of implemented methods contained in the	EP1	

Metrics	Category	Factor	Description	Reference
			mobile application source code	
		Number of all code lines	Total number of mobile application source code lines	EP1
		Number of lines containing source code	Total number of lines containing mobile application source code	EP1
		Number of lines containing comments	Total number of lines containing mobile application source code comments	EP1
		Number of declarations	Total number of declarations contained in the mobile application source code	EP1
		Code size (kB)	Size of the mobile application in kB	EP11
		Number of XMI files related to graphics for a mobile application.	Number of XMI files related to graphics (for example, text box, and so on) of a mobile application	EP11
	Complexity	Cyclomatic Complexity	Measure of complexity, where one considers the independent paths that the project code can take.	EP1
	Functionality	Function Point Analysis	Function points calculated using the Function Point Analysis method	EP2
		FISMA	Function points calculated using the FISMA method	EP02
		COSMIC	Function points calculated using the COSMIC method	EP3, EP4, EP11, EP12, EP13, EP14, EP15
		Variation of the COSMIC method	Function points calculated using the method proposed by Abdullah et al. 2014.	EP14, EP15
Cost Factors	Development Team	Team Communication Level	Degree of communication among team members that can range from low, medium to high.	EP5, EP6
		Experience Level of Development Team	Degree of experience in programming and database development that can range from low, medium to high.	EP1, EP5
		Team experience in the context of the application	Whether team members have experience or not in the context of the application, for example knowledge in the areas and business applications.	EP1, EP5
		Definition of team roles	Whether or not the roles of team members are defined.	EP5
	Company	Level of certification of the company	Whether or not the company is certified.	EP6
		Software and hardware failure level	The frequency of software and hardware failures that can vary from never, rarely to	EP6

Metrics	Category	Factor	Description	Reference
			always.	
		Involvement of competitors	Whether or not competitors are involved.	EP6
		Supplier Competence Level	Competence is related to meeting the deadlines and quality of delivery of the raw material. The degree of competence can vary from low, medium to high.	EP6
	Client	Competence level of users and clients	Customer's competence may be low, medium or high.	EP6
		Expectations level of users and customers	Degree of customer expectation can vary from low, medium to high.	EP6
	Project	Preparation level of change management	The degree of preparation for eventual changes that may occur during the project is extremely relevant. This degree can range from maximum preparation for change, reasonable preparation for change, to minimum preparation for change.	EP5
		Level of Definition of Stakeholder Objectives	Whether or not the objectives are defined.	EP5
		Validation and verification process and implementation	Whether or not there is a verification and validation and implementation process.	EP5
		Test in real environment	Whether or not the test is performed on end users' devices.	EP5
		Measure the process	Whether or not each step of the project process is measured.	EP5
		Understanding the costs of modifications	Whether or not to calculate the costs of modifications before doing them.	EP5
		Types of back-end systems (CMS, web site, ERP, CRM ...)	The application has a back-end system with low complexity, the application has two back-end systems with average complexity and three or more with high complexity.	EP3, EP4
		Existing software bugs	It consists of the frequency of bugs in the software that can vary from never, rarely, sometimes to always.	EP5
		Use of native APIs (Higher Effort)	Using mobile device native APIs to write applications requires more effort and non-use requires low effort.	EP5
	Product			
	Data Network	Network bandwidth	° (-) The application should require the maximum bandwidth.° (+/-)The application should require	EP2, EP4, EP5

Metrics	Category	Factor	Description	Reference
			reasonable bandwidth. ◦ (+) The application will require a minimum bandwidth.	
		Wifi switching	The application should work offline and online. If it is offline it will be less complex than online because it will depend less on communication with servers and other factors.	EP2, EP4
		Types of Network Connectivity	◦ (-) The application must have the utmost predisposition to use connections such as 3G, Wi-Fi, Wireless, Bluetooth, Infrared and others. ◦ (+/-) The application must have reasonable predisposition to use connections such as 3G, Wi-Fi and Wireless. ◦ (+) The application should only have a predisposition to use connections, which can be: 3G, Wi-Fi, Wireless, Bluetooth, Infrared or others.	EP2, EP4
		Database Synchronization	Level of complexity to synchronize with the database that can vary from low to local applications, average to applications that save local and then send to the server or high that connects to server to be able to synchronize with the database.	EP5
	Interface	Graphic Interface Input Variation	The Interface Entry can have: The application must have input interfaces for touch screen, voice, video, keyboard and others or the application must have standard input interfaces for keyboard or the application should have any of the interface types, such as: touch screen, voice, video, keyboard or others.	EP2
		Visual quality	Adjusting UI components for playback of a corporate project, logo, corporate branding, navigation, animations. Complexity low if few components, medium complexity if the number of interface components is reasonable and complexity high if many components to adjust.	EP3
		Modes of presentation	Portrait and landscape mode. It refers to whether the screen is only portrait or landscape	EP3, EP4

Metrics	Category	Factor	Description	Reference
			without changes (less complexity) or if the application supports landscape and portrait mode (greater complexity). Ex: Google Calendar, portrait mode is a screen format and landscape mode totally modify the interface and arrangement of the components.	
		Size of Mobile Device Screens	The limitations of the application are due to the screen size that can be according to the mobile device used: The application has limitations because it will be used mainly by mobile phone users or the application has a reasonable limitation because it will be used by both the Mobile phone and tablet users, or the app has little limitation because of the screen size because it will be used primarily by tablet users.	EP2, EP3
	Hardware limitation	Low Battery Consumption	Battery consumption may vary from application and should be concerned with optimizing features for lower battery consumption, optimization of features for lower battery consumption may or may not exist or optimization of features for lower battery consumption should not be taken into account.	EP2, EP4
		Call interruptions	Whether or not there is treatment for call interruptions.	EP4
		Performance Factor	Performance consists of optimizing resources for better efficiency and response time that may vary: Be concerned with optimization, may or may not exist or should be taken into consideration.	EP2, EP4
	Portability	Portability between operating systems	Whether or not there is portability between operating systems.	EP3, EP5
		Compatibilidade entre emuladores e dispositivos móveis	Se foi ou será realizado o teste em emuladores e dispositivos móveis.	EP6
	Non-Functional Requirements	Collaboration Level	The degree of relationship in which multiple agents participate in a single instance of the application. Example:	EP8

Metrics	Category	Factor	Description	Reference
			number of devices used in the virtual fence that delimit a herd of cattle. According to the number of collaborations the scale varies from: the application should require maximum collaboration or the application should require reasonable collaboration or the application will require minimal collaboration.	
		Application instance lifecycle	The length of time that an application instance runs. According to the lifetime number the application should require a maximum lifetime or the application should require a reasonable lifetime or the application will require a minimum lifetime.	EP8
		Absolute Location Awareness	The location is a position in a geographic coordinate system. Applications that require knowledge of absolute location typically use methods such as GPS or signal triangulation whether the application has it or not.	EP8
		Space Awareness	Buildings, malls and etc - Consider whether the device is within the defined limit area of places whether the application has it or not.	EP8
		Response Time Restriction	The application accepts output delay or requires real-time. According to Response Time Restriction the application must require a real-time response time with maximum accuracy. It consists in the existence or not of this concern in the restriction of the response time.	EP8
		Proximity Awareness	Proximity awareness (approach sensitivity). According to Proximity Awareness, the application should require or not a sensitivity of approximation with precision.	EP8
		Event Awareness	Knowledge of events in the application environment. Top-level events can be extracted from the occurrence of other events whether the application has it or not.	EP8
		Application Purpose	(Entertainment, Operational or other)	EP8

Metrics	Category	Factor	Description	Reference
		Transition Awareness	The degree to which an application's behavior depends on the knowledge of transitions between spaces whether the application has or does not.	EP4, EP8
		Object Awareness	Awareness of other objects in the system and their status. Example: An electronic chemistry lab book allows chemists to automatically record non-instructive experiments for further analysis whether the application has or does not.	EP8
		Advertising (ads)	Whether the application has advertisements or not.	EP3
		Augmented Reality	Whether or not the application uses this type of technology.	EP3
		Operational Awareness	An application's behavior depends on the system's history awareness, such as the context of a workflow, whether the application has it or not.	EP8
		Centricity	Data collection or execution of actions in response to the environment whether the application has or does not.	EP8
		Tracking System	Helps find a lost device whether the application has it or not.	EP3
		Security level	Application security may vary from low, medium, to high.	EP4
		Quality Level of products	Product quality can range from low, medium to high quality.	EP6

3. Classification of Mobile Application Effort Predictors using Taxonomy

The set of predictors from the qualitative study and systematic mapping had 122 predictors (26 size metrics and 96 cost factors) that underwent a terminology control to remove duplicates, resulting in 108 predictors (23 size metrics and 85 cost factors).

With this, a taxonomy of effort predictors for mobile application projects was defined that assists professionals in the process of decision making and knowledge sharing. With the taxonomy, the unified predictors were classified into the 12 taxonomy categories as shown in Table 5 through Table 11. Note that the "F" column shows the frequencies of each factor in all tables. The legends of references P1 to P8 are the qualitative study participants detailed in Appendix A and the legends of references EP1 to EP15 are the predictors coming from the systematic mapping of the literature detailed in Table 3.

Tabela 5: Fatores relacionados a Métricas de Tamanho

Subcategory	Factor	Description	References	F
Length	Number of Functional Requirements	Number of functional requirements of the project.	EP1, P7	2
	Number of Actors in the Use Case	Total number of Actors in the project use case can be descriptive or diagram.	EP1	1
	Number of Use Cases	Total number of Use Cases can be descriptive or diagram.	EP1	1
	Number of Requirements Document Classes	Total number of Classes of the project, can be descriptive or diagram.	EP1	1
	Number of Sequence Diagrams	Total number of Sequence Diagrams of the project.	EP1	1
	Amount of Data	The amount of data the application contains, for example, commerce and e-commerce applications have product and customer data.	P1, P3, P4	3
	Number of Source Code Classes	Total number of Classes contained in the mobile application source code	EP1	1
	Number of Source Code Files	Total number of project files	EP1	1
	Number of Methods (Including Inherited)	Total number of implemented methods contained in the mobile application source code	EP1	1
	Total number of lines	Total number of lines of mobile application source code	EP1	1
	Number of lines containing source code	Total number of lines containing only mobile application source code	EP1	1
	Number of lines containing comments	Total number of lines containing only mobile app source code comments	EP1	1
	Number of declarations	Total number of declarations contained in the mobile application source code	EP1	1
	Code size (kB)	Mobile application size in kB	EP11	1
	Complexity	Number of XMI files related to graphics for a mobile application	Number of XMI files related to graphics (for example, text box, and so on) of a mobile application.	EP11
Number of graphical interface elements		Number of different types of elements that the GUI contains, for example, there are applications that require logo, corporate branding, navigation, animations, different effects and have usability concerns.	EP3, P4	2
Complexity	Cyclomatic Complexity	Measure of complexity, where one considers the independent paths that the project code can take.	EP1	1

	Level of Application Context Complexity	If the application needs to be studied the context that the application will be taken into consideration. Example: stock exchange and banks. This level of complexity can range from low, medium, to high.	P2	1
Functionality	COSMIC	Function points calculated using the COSMIC method	EP3, EP4, EP11, EP12, EP13, EP14, EP15	7
	IFPUG	Function points calculated using the IFPUG method	EP2	1
	FISMA	Function points calculated using the FISMA method	EP02	1
	COSMIC with UML model mapping	Function points calculated using the method proposed by Abdullah et al. 2014.	EP14, EP15	2
	Total time to make the application screens	Indicates amount of time spent for each application screen (for example, time to make icons and gifs and others).	P1, P3	2

Table 6: Client-related Factors

Factor	Description	Legend	F
Users' and clients' Competence level	It involves knowing the business and knowing how to pass information. Customer's competence may be low (when the customer passes the wrong information), average (when the customer knows the information but does not know the part of the project implementation) or high (when the customer is aware of the problem and knows the part of project implementation).	EP6, P1, P2, P4, P6, P8	6
Users' and clients' expectations	Situation of whom expects something to occur, or its probability of occurrence, at any given time. Whether or not the client has expectations about some aspect of the project.	EP5	1
Customer autonomy in decision making	Whether or not the client has the autonomy to make a decision on the project.	P7	1
Level of Communication with the Client	It involves the communication of those responsible for the project with the client, which can vary from rarely communicate, almost always have communication or always have communication with the client.	P1, P2, P3, P6	4
Level of Customer Participation	If the customer validates the project specifications, if the client is aware of the project risks, if the customer participates in the product design meeting, these are examples of participation. Participation may vary from low (when the customer only participates in design meetings), average (when the customer participates in meetings and validates the specifications) or high (when the customer is present throughout the project development).	P1, P2, P3, P4, P5, P6, P7, P8	8

Table 7: Company-related factors

Factor	Description	Legend	F
Level of Company Tooling Infrastructure	Availability of rooms for work and tooling that may vary from always available, rarely to never.	P8	1
Company Certification Level	Whether or not the company has certifications.	EP6	1
Suppliers Competence	Competence is related to meeting the deadlines and quality of delivery of the raw material. It consists of whether or not they are competent.	EP6	1
Competitors' Involvement	Whether or not competitors.	EP6	1
Company Internet Availability Level	It consists of the level of stability/availability of the company's internet access that can range from never stable, sometimes stable to stable.	P3, P7	2
Availability of Test Devices	Whether or not devices are available to test the application.	P7	1
Availability of the Infrastructure to speak with the Client	Whether or not there is an infrastructure to talk to the customer.	P6, P8	2

Table 8: Factors related to the Development Team

Factor	Description	References	F
Level of Experience with Technology	The level of experience with the technology that the project needs can vary from none, low (did some learning exercises), average (did some projects with technology) or high (did many projects with technology).	P1, P2, P3, P4, P5, P6, P7, P8	8
Team experience in the context of the application	One may have experience or not in the context of the application, for example, knowledge in the areas and business applications.	EP1, EP5, P2	3
Level of team Communication	Level of communication among team members that may vary from low (when communicating only in some meetings), medium (when communicating at all meetings) or high (when communication is frequent).	EP5, EP6, P2	3
Level of Experience in Development in Previous Projects	Level of development experience in previous projects can vary from none (when they have never worked with a project), low (when they worked on a project), average (when they worked on some projects) or high (when they worked on many projects).	EP1, EP5, P1, P2, P3, P5, P7	7
Number of dedicated hours of each project by person	It consists of the number of hours each person works on the project.	P4	1
Definition of team roles	Whether or not the roles (developer, tester, and others) of team members are defined.	EP5	1
Level of Team Competency Knowledge	When one knows the competence of the team that he/she is participating in the project. This knowledge of team competency can vary from none (when he/she has not worked with team members in project development), low (worked on only one project), average (worked on some projects) to high (worked on many projects).	P1, P2	2
Number of People Working on the Project	It consists of the number of people working on the project.	P2, P4, P6	3
Team Learning Curve	It consists of the necessary time in hours for the team to learn some resource, project context or technology needed for the project.	P1, P6	2

Level of Team Engagement	Team engagement with the project can range from low (when the team is dispersed), medium (when the team becomes available to meet) or high (when the team takes the project forward and the team passes the trust that is involved in solving a problem).	P2, P4, P6	3
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Table 9: Product-related Factors

Factor	Description	Legend	F
Network bandwidth*	(-)The application should require a maximum bandwidth. (+/-)The application should require a reasonable bandwidth. (+)Application requires minimal bandwidth.	EP2, EP4, EP5	3
Network Access Switching*	(-)The application must work offline and have a synchronization. (+/-)The application must work offline and it is not necessary to have a synchronization. (+)The application should not work offline.	EP2, EP4	2
Mobile Device Connectivity Type*	(-)The application must have the maximum predisposition to use connections such as: 3G, Wifi, Wireless, Bluetooth, Infrared and others. (+/-)The application must have reasonable predisposition to use connections such as: 3G, Wi-Fi and Wireless. (+)The application should only have a predisposition to use connections, which can be: 3G, Wi-Fi, Wireless, Bluetooth, Infrared or other.	EP2, EP4, P1	3
Request for Internet	If it is a client-server application, it must estimate the alternative paths in case the request returns with failure or success. Whether or not this feature is used, if used, alternative paths should be estimated as well.	P5	1
Communication format with the Server	It is an open standard format that uses human-readable text to transmit data objects consisting of attribute-value pairs. This communication format with the server can be Json or XML.	P4, P5	2
Dependencies with other systems	Whether there is a dependency with another client system or another API or there is no dependency.	P5	1
Synchronization with database	Whether or not the application uses database.	EP6	1
Graphic Interface Input Variation*	(-) The application should have input interfaces for touch screen, voice, video, keyboard and others. (+/-) The application must have standard keyboard input interfaces. (+) The application should have any of the following types of interfaces: touch screen, voice, video, keyboard or other.	EP2	1
Application Presentation Mode	Whether or not there is a differential treatment for the mobile device's horizontal or vertical screen.	EP3, EP4, P1, P6, P7, P8	6
Size of Mobile Device Screens*	(-) The application has limitation, due to the screen size, since it will be used mostly by mobile device users. (+/-) The application has a reasonable limitation, due to the screen size, as it will be used by both mobile and tablet users. (+)The application has little limitation, due to the screen size, because it will be used by mostly tablet users.	EP2, EP3, P2, P6	4

Mobile Device Power Limitation *	Depending on the application types (games, for example) there is a concern in optimizing the use of resources because of the device's power limitation. This concern may vary: (-) The application should be concerned with optimizing features for lower battery consumption. ◦ (+/-) Resource optimization for lower battery consumption may or may not exist. ◦ (+) Resource optimization for lower battery consumption should not be taken into account.	EP2, EP4, P1, P3, P4	4
Call Interruptions	When an application is stopped or paused to perform a phone call. It consists in the existence or not of this concern in call interruptions.	EP4, P2, P3	3
Performance Factor*	◦ (-) The application should be concerned with optimizing resources for better efficiency and response time. ◦ (+/-) Optimization of resources for better efficiency and response time may or may not exist. ◦ (+) Optimization of resources to improve efficiency and response time should not be taken into account.	EP2, EP4	2
Operating System of the Mobile Device	Takes into consideration or not the operating system version and the operating system: Android and IOS.	P1, P6, P7, P8	4
Portability between operating systems	Ability of the application to be compiled or run on different operating systems. It consists in the existence or not of the portability between the operating systems.	EP3, EP5	2
Compatibility between emulators and mobile devices	Whether or not the tests were/will be performed on emulators and mobile devices.	EP6	1
Targets	Number of devices on which the application will run.	EP3, EP6, P2, P6, P7	5
Integration with social networks	Some application features use social networking features like login, content sharing, invite friends, and so on. This factor is measured in the use or non-use of social networks.	P3, P4, P5	3
Advertising (ads)	Disclosure of any company, service or product, whether or not the app has ads.	EP3	1
Application instance lifecycle	The length of time that an instance of the application runs. An application can run from a few seconds to several days or years. The longevity of an application instance impacts power requirements and what degree of persistence the infrastructure is needed.	EP8	1
Application Purpose	The purpose is the type of benefit to be achieved from the application that may be simply entertainment or it may be increasing access to information or performance. The objective can affect, among others, the security, reliability and quality of the architecture.	EP8	1
Collaboration	The degree of relationship in which multiple agents participate in a single instance of the application. Example: number of devices used in the virtual fence that delimit a herd of cattle.	EP8	1
Absolute Location Awareness	Absolute location is a position in a system of geographic coordinates. Applications that require knowledge of absolute location typically use methods such as GPS or signal triangulation. This is whether or not the application uses this feature.	EP8	1
Space awareness	Consider whether the device is within the defined limit area of places (Buildings, malls and etc). This refers to whether or not the application uses this feature.	EP8	1

Response Time Restriction	Whether the application has real-time or is delay tolerant. Applications may accept some delay in output or require a real-time response. Real-time applications often indicate the need for more reliable bandwidth than delay-tolerant applications.	EP8	1
Proximity Awareness	Sensitivity of approach to a particular object or place. Proximity sensitization in general indicates the need for methods such as sensors. This is whether or not the application uses this feature.	EP8	1
Event Awareness	Knowledge of events in the application environment that requires system capabilities. Top-level events can be extracted from the occurrence of other events. This is whether or not the application uses this feature.	EP8	1
Transition Awareness	The degree to which the behavior of an application depends on the knowledge of transitions between spaces. This is whether or not the application uses this feature.	EP8	1
Object Awareness	Awareness of other objects in the system and its states. Example: An electronic chemistry lab book allows chemists to automatically record non-instructive experiments for later analysis. This is whether or not the application uses this feature.	EP8	1
Augmented Reality	The integration of virtual information and real-world views in real time. Whether or not the application uses this type of technology.	EP3	1
Operational awareness	The behavior of an application depends on the awareness of the history of the system, such as the context of a workflow. This is whether or not the application uses this feature.	EP8	1
Centricity	Data collection or implementation of actions in response to the environment. Whether or not the application has this feature.	EP8	1
Tracking System	Helps find a lost device. Whether or not the application has this feature.	EP3	1
Security	Protection of a set of information from an individual or an organization. Whether or not the application has this feature.	EP4	1
Product quality	It meets users' and customers' needs, meets the project requirements. Whether or not the application has this feature.	EP6	1

Table 10: Factors related to Mobile Application Projects

Factor	Description	Legend	F
Preparation of change management	Whether or not there is preparation for eventual changes that may occur during the project is extremely relevant.	EP5	1
Documentation Level of the Project	Project documentation is a record of all phases of the project, what decisions were made, how and why. They consist of: no documentation, documentation with little detail, or more detail.	P2, P8	2
User Interface (UI) Document	Formal specification that shows the application's design decisions. It consists of using or not User Interface (UI) Document to estimate the project.	P8	1
User Experience Document (UX)	Formal specification that focuses on hedonic aspects such as user emotions and stimuli while interacting with an application. It consists of using or not the User Experience (UX) Document to estimate the project.	P8	1

User Stories	Concise description of an application user's need from this user's point of view. It consists of using or not using User Stories to estimate the project.	P2, P6	2
Project Confidentiality	Whether or not the project requires confidentiality of project information.	P4	1
Changes	Whether or not there is control of the changes that are made in the project.	P4	1
Risks	Whether or not the project is clear of existing risks.	P2	1
Project Migration	Whether or not the project is prepared for a possible migration.	P1	1
Scope Type	Whether the scope is open (not defined requirements) or closed (all requirements are defined).	P6	1
Level of Requirements Definition	The degree of requirements definition may vary from low (requirements are not defined), medium (a part of requirements is defined) to high (all requirements are defined).	P5	1
Stability of Requirements	It consists of determining whether or not the requirements are stable.	P1, P7	2
Variation of ways to perform the same functionality	Whether there is a variation of ways to perform the same functionality or not. Example: the form of payment that can be by bank slip, credit card or PayPal.	P4	1
Project Premise	Premises are factors associated with the project scope which, for planning purposes, are assumed to be true, real or certain, without the need for proof or demonstration. Whether or not a survey of the project premises is/will be carried out.	P8	1
Definition of Stakeholder Objectives	Whether or not the objectives of the stakeholders are defined.	EP5	1
Flexibility of Development Methodology	Whether or not there is Flexibility in Development Methodology.	P4	1
Task Dependency	Whether or not there is any task dependent on another.	P5	1
Identification of MVPs	Version of a product that can be launched with a minimal amount of effort and development. Whether or not the project's Minimum Viable Product is/will be identified.	P7, P8	2
Identification of Personas	Personas are fictional characters used to represent users in terms of their goals and personal characteristics. Whether or not the Personas are identified.	P7	1
Product Vision Identification	Product vision is the product's <i>raison d'être</i> , it should direct all decisions regarding this product. Whether or not the product vision is identified.	P7	1
Product Design Techniques	Whether or not product design techniques are used.	P7	1
Validation and verification process and implementation	Whether or not there is a verification and validation and implementation process.	EP5	1
Test in real environment	Whether or not the test is performed on end users' devices.	EP5	1
Measure the process	Whether or not each step of the project process is measured.	EP5	1
Understanding the costs of modifications	Whether or not to calculate the costs of modifications before doing them.	EP5	1

Table 11: Technology-related factors

Factor	Description	Legend	F
Software and hardware failure level	The frequency of software and hardware failures that can vary from never, rarely to always.	EP5, EP6	2
Use of APIs	API is a set of routines and standards established by a software for the use of its features by applications that are not intended to be involved in software implementation details, but only to use its services. Whether or not some API is used, (Client or native API).	EP5, P4	2
Types of back-end systems	Back-end systems are responsible for implementing the business rule, for example CMS, web site, ERP, CRM. If the application has a back-end system, complexity is low; if the application has two back-end systems, the complexity is average; and for three or more, the complexity is high.	EP3, EP4	2

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