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A practice for specifying user stories in multimedia system design: An approach to reduce ambiguity

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Abstract. Various agile approaches have guided the development of solutions based on a minimum viable product for the use of user stories (USs). These approaches provide a generic process for specifying USs for a wide variety of solutions. This study presents an original proposal for a practical approach to the specification of USs for multimedia systems, expressed using the Essence graphical notation language. The practice includes a set of activities, techniques, and tools that can be used by professionals to define the USs of a multimedia system, and which can help to mitigate potential ambiguity problems such as vagueness and insufficiency in formulation. To explore its application, a case study was carried out with the participation of two groups of professionals: an experimental group, and a control group. The results for the analysis factors are promising, and show that by carrying out the activities that make up the practice, a work team can achieve the specification of USs at three levels of concreteness, which contribute to the reduction of problems of vagueness and insufficiency in the USs of a multimedia system. Using this approach, the USs can be guaranteed to meet the value proposition of the multimedia system that will be implemented.

Keywords: User stories, Multimedia systems, Specification, Ambiguity.

1 Introduction

User stories (USs) originated as one of the elements used in the eXtreme Programming (XP) Planning Game. The first written description of these was presented in 1998, and stated that customers define the scope of a project "with user stories, which are like use cases" [1]. Their use in the field of software development is closely linked to agile work approaches, and their main purpose is to articulate the way in which a software function will provide value to the user [2].

The explicit orientation offered by USs for the creation of value for the user encouraged the discussion and alignment of aspects related to user experience (UX) and the agile paradigm for the development of products based on interactive systems. The application of USs as a mechanism to align the UX with the functional aspects of the system enabled the emergence of new working techniques, such as the generation of US maps [3]. However, their application in the development of interactive

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software-based systems has been mainly as artefacts that guide the agile development process based on methodologies such as SCRUM and XP.

Agile methodologies have undoubtedly enriched the development of software-based products with new approaches and perspectives [4]. However, while traditional agile lifecycles such as SCRUM have offered notable contributions to the software development industry, they also suffer from certain limitations when it comes to achieving a higher degree of specification in the UX design of a given solution [5].

In contrast, a multimedia system (MS) is defined as one that allows for value creation for interested parties through the deployment of an interactive multimedia experience (IME), using an ethic and responsible design approach, and addresses the users' needs, interests and expectations by influencing their human senses via storytelling using digital media resources [6]. The original motivation for the realisation of this research work arose from the question of what a traditional agile methodology such as SCRUM or XP can offer in terms of the specification of USs associated with an IME [6]. This arose from the potential offered by the use of USs to carry out the specification of a software system, with a focus on the needs and interests of the user regarding the solution, while also recognising the intrinsic limitations arising from the use of a semi-structured language for the specification of a US. These limitations refer, for example, to the ambiguity that may arise from the doubtful and imprecise interpretations to which the US can lead, a current problem that continues to be studied by several authors [7][8].

Our research offers a new working approach to the process of specifying USs for IMEs. The proposal is presented in the form of an artefact [9] that represents a procedure for the specification of USs using the Essence graphical notation language [10]. The practice includes a work path that defines specific activities, techniques and tools that can guide multimedia systems development teams. This contribution aims to mitigate the occurrence of ambiguities, namely vagueness [11] and insufficiency [12] in the use of USs in the specific domain of multimedia systems development. The practice was validated via a case study involving two professionals groups: and experimental and a control group. The outcomes are promising, as the experimental group successfully met the US specifications, demonstrating a decrease in issues related to vagueness and insufficiency within the US, in line with the predetermined analysis criteria.

This article is organised as follows: Section 2 describes the background related to this study. Section 3 describes the materials and methods applied in this research. Section 4 presents the results of the case study. Section 5 contains a discussion of the results. Finally, Section 6 gives our conclusions and suggestions for future work.

2 Background

2.1 Application of Agile Methodologies to USs

A background study and documentation review were carried out using a systematic literature review methodology [13], which is widely accepted as a qualitative approach to research in disciplines such as software engineering [14].

The findings of the study [15] made it possible to identify software engineering, human-computer interaction, and, primarily, user-centred design (UCD) as the main disciplines on which most of the existing methodologies and frameworks for MS development are based. This gives rise to a need for distinct work approaches to address the traditional requirements engineering lifecycle [16]. However, emerging proposals related to the production of MSs are moving towards the application of practices that involve techniques based on agile methodologies for their development [17].

Some authors have reported difficulties in applying agile methodologies to work with UX [18]. One of the main reasons for this is the focus on the development process in these methodologies. Despite this difficulty, agile approaches also offer artefacts such as USs, which favour UX design under a UCD approach, since their structure is based on the user's perspective as opposed to the functionality requirements of the system [19]. This has led several researchers to adapt agile practices and methodologies to work on UX through USs [20]. Such efforts are justified given the constraints imposed by traditional requirements engineering on UCD in contrast with USs, as shown in Table 1.

Table 1. Comparison of requirements engineering vs. user stories

Traditional requirements engineering practices	User stories	Analysis for the benefit of UX design
Lead to the development of robust documentation as a basis for requirements analysis, specification, and validation	Focus on the generation of collaborative workspaces that promote synchronous and verbal communication among stakeholders	Collaborative work and permanent communication spaces among stakeholders for the generation of user stories favour UX design
Focus on the functionalities to be performed by the system, or how the system should behave in different situations	Focus on the people (commonly the user), the action to be taken, and its value proposition	Discussions with a focus on creating value for the user can enrich the contribution that the product can offer to the UX
Facilitate the application of a process flow for waterfall development	Favour the application of an iterative and incremental UCD process flow	The UX design process is enriched through iteration and continuous advancements that occur as a result of ongoing stakeholder engagement cycles during the production of the solution

The challenge of integrating UX with agile methodologies has extended to other work approaches, such as LEAN UX methodologies for LEAN startups [21]. In its convergence between UX and agile work approaches, LEAN UX faces challenges that are more related to results than to the production of detailed deliverables (as in traditional UX), where the concept of the minimum viable product (MVP) takes on special relevance for UX design [22].

The background discussed in this section illustrates the multiplicity of initiatives around research work focusing on the convergence between UX and agile methodologies. However, this contrasts with the scarcity of methodologies for the development of interactive systems and MSs that adopt such techniques within their development activities and practices. As a result, an initiative that allows for convergence between the design of interactive MSs and agile techniques focused on UX has been developed. In particular, it relates to the conception of a minimum viable systems (MVMS), which defines the specification of an IME [6].

Table 2 presents a summary that classifies the different forms of existing work based on a set of characteristics that are relevant to this research. These approaches have been grouped into three types: traditional LEAN UX, methodologies focused on the development of interactive systems, and practices focused on the design of a MVMS. The last of these approaches involves practices based on a LEAN UX approach specifically for the design of a particular MVMS [17].

In Table 2, the agile feature indicates whether a set of work approaches uses agile practices for the development of the solution, whereas the UX feature specifies whether or not the methodologies are centred on UX principles. The US feature shows whether a given work approach uses USs as the solution for the solution specification. The multimedia/interactive system feature indicates whether the focus of the work is specifically centred on the development of a multimedia/interactive system. Finally, the full life cycle feature specifies whether or not the work approach covers the entire life cycle scope for product development.

Table 2. Comparison between LEAN UX-based work approaches and interactive MS development

Feature	Traditional LEAN UX	Approaches to the development of interactive MSs	Practice for the design of a MVMS
Agile	Yes	No, except for the adaptation of MPIu+a [23]	Yes
Embraces the UX	Yes	Focused mainly on UCD	Yes; focused on an IME
User stories	Yes	No; traditional requirements engineering prevails	No
Based on the development of multimedia/interactive systems	No; generic and potentially applicable to different types of products	Yes	Yes
Full life cycle	Yes	Yes	No

As can be seen, LEAN UX is a working methodology that covers the entire product lifecycle, and is based on an agile and UX approach. Similarly, it can be observed that the work approaches for the development of multimedia and interactive systems prioritise the activities and techniques used in UCD, but there are few adaptations of agile and UX-oriented work approaches that are documented and offer accurate results. Likewise, the use of traditional requirements elicitation is still a dominant practice in the different working methodologies for the development of interactive and multimedia systems in the literature [15].

Considering the aforementioned, the methodologies reviewed for the development of MS show limited evidence regarding the utilization and application of best practices for US specification. Given that an IME encompasses elements such as digital media, sensory perceptions, interaction modalities, responsible design, and emotions, it is acknowledged that certain methodologies prioritize US quality. Nonetheless, traditional models may neglect aspects like those mentioned above. Consequently, the omission of these components could exacerbate issues of vagueness and insufficiency in US specifications for MS.

2.2 Vagueness and Insufficiency and their contribution to ambiguity in user stories

In a recent review by Amna et al. [7] of the state of the art related to ambiguity in USs, it is noted that a lack of clarity related to the meaning of a US is one of the main aspects contributing to the problem of vagueness, and that this is transversal across all linguistic levels [11], particularly when the semi-structured language used for its specification is not English [24]. The absence of a clear scope for the development of the solution, which would assist in a better interpretation of the US, is also considered a significant factor contributing to its vagueness and affecting its implementation [25]. In view of this, we highlight works presented by other authors that associate the vagueness of a US with the absence of methods for specifying the higher-level objectives of the software system [26].

Another problem associated with ambiguity in the formulation of a US is insufficiency, which is related to the possibility that the USs are incomplete in scope concerning a task that the user should be able to perform through the use of the software system. Several studies have associated this situation with the presence of unattended requirements, which do not allow the user to complete the different tasks to be performed by the system [27]. Another factor that contributes to insufficiency in the formulation of USs is related to scenarios where there is a high degree of personnel turnover [28], due to the need for traceability of information about the communication between users and the design team during the design and specification stages of the software system.

As a US ambiguity problem, inadequacy can cause uncertainty and confusion among developers and other stakeholders, which in turn can lead to delays and incorrect implementation of the software system [29].

In view of the above discussion, this article proposes a practice for the specification of USs in the context of interactive MS design, as an alternative to traditional work approaches. It can contribute to mitigating potential ambiguity problems such as vagueness and insufficiency in its formulation, through the use of techniques and tools which reduce the factors that produce such problems.

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3 Materials and Methods

3.1 Practice for the Specification of US in MS Design: MSUS

The proposed MSUS practice facilitates the elicitation, analysis, specification, and validation of USs for a MVMS, and is used to ensure the necessary conditions to proceed with the production of the MVMS. The specification path is responsible for providing the sequence and form of iteration of the different activities that compose it. The practice is made up of a series of design patterns, such as the route for the specification of a US, the activities, techniques, and tools that allow for its application, and a sub-alpha of US of the MS, which allows the work teams to keep track of the execution status of the set of activities that make up the practice.

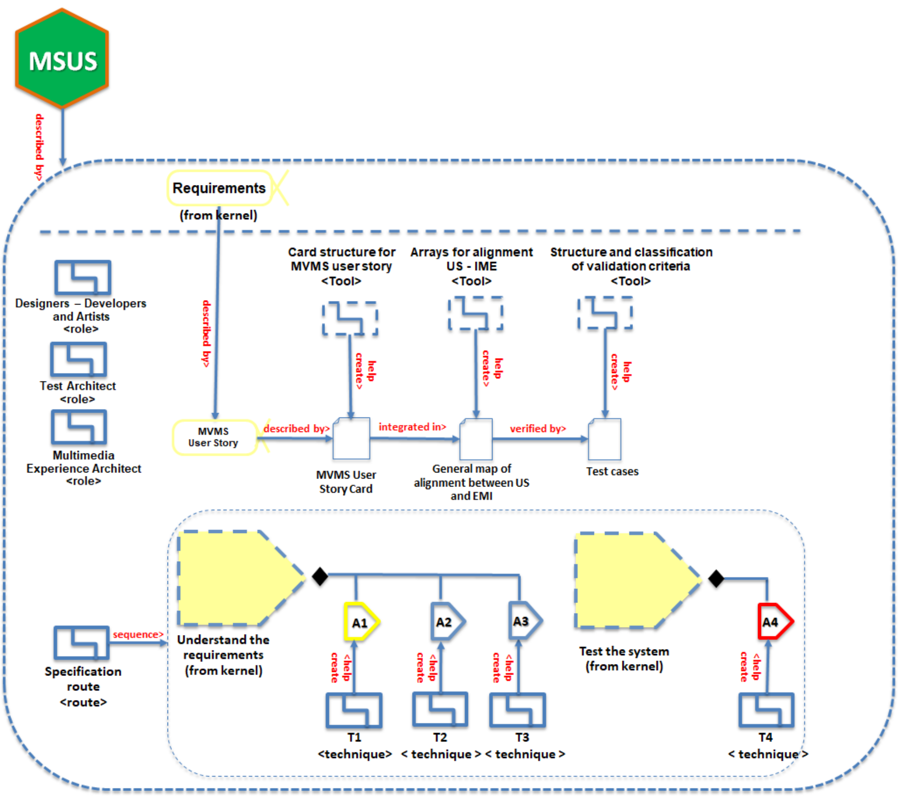

Fig. 1. Structure of the proposed practice for the specification of user stories in the design of multimedia systems.

Figure 1 shows the practice for US specification in multimedia system design (MSUS) as a solution artefact. Its design is based on the principles of Essence, the graphical notation language of the software engineering standard [10]. Essence is a simple model of the challenges that all software development teams face, and is coupled with a visual language to capture practices to help teams address those challenges. The model includes practices, alphas, activities, roles, etc. [10]. Essence enables practices and related knowledge to be expressed in a simple, visual way that ensures that they can be easily shared, understood, adopted, adapted and applied, both independently and in combination with other practices (such as the MVMS practice [17]). In view of this, our practice is designed from the context of the Essence kernel solution area of interest. This allows us to visualise the interrelationships between the activities, techniques, tools, work products, alphas, and roles involved, in order to achieve the purpose and demonstrate the scope of the practice.

It is important to emphasise that this practice establishes the need to previously count on the conception of the IME for the definition of the US. For this reason, the techniques proposed for the practice rely on the sources of information identified at the conception stage of the IME, such as the value proposition of the MS, a clear and concrete definition of the scope of the MVMS, and high-fidelity prototypes.

Specification route. The route pattern for the US specification is made up of a set of activities (shown in Figure 1 as pentagons) and techniques (shown as rectangles), following the patterns of the Essence standard graphical notation language [30]. The main function of a route is to suggest the flow of activities and their associated techniques to the work team. Figure 2 presents a simple illustration of a suggested flow for the execution of the activities that make up the pathway [6]. In this case, the activity shown in yellow is suggested as the first one used by the work team to initiate the process of specifying the US, while the red one represents the activity that finishes an iteration during the process.

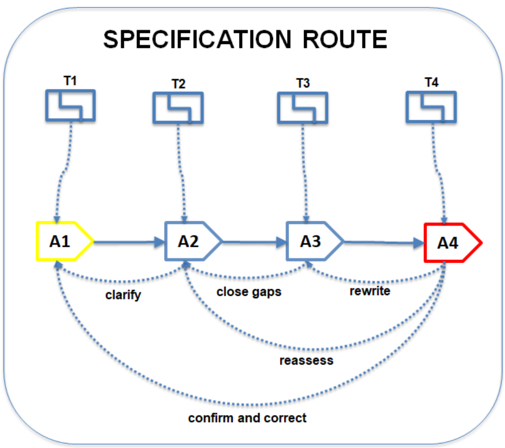

Fig. 2. Specification route for a US.

Table 3 lists the set of activities that make up the practice for the specification of USs through the specification path, while Table 4 shows the association between each

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activity and the techniques involved, and offers a step-by-step process for their application and a set of associated tools as a foundation guide.

Table 3. Activities making up the US specification practice

Activity code	Activity
A1	Elicitation of US and its alignment with the IME
A2	Analysis of US with a focus on the IME
A3	Specification of USs aligned with the IME
A4	Validation of USs

Table 4. Activities making up the US specification practice

Activity	Technique code	Technique	Step-by-step	Tools
A1	T1	A general mapping of the alignment of the US with the IME	1. Identify the set of epic USs at the first level, which support the general history in which the IME is inscribed. 2. Order the epic USs from beginning to end, taking into account time or event considerations 3. Identify the USs that make up the IME at the second level, which are related to the needs to be satisfied, based on the dimensions of multimedia content, responsible design, and emotions 4. Establish a cause-and-effect relationship between the second-level and first-level USs 5. Define a third level of US candidates for production 6. Establish a cause-and-effect relationship between the third-level and second-level USs	User stories map [3] User story generation guide [31] COBIT Balanced Scorecard [32]
A2	T2	Analysis of USs	1. Conduct a completeness analysis of the second-level USs in regard to the epic USs that make up the IME 2. Include, adjust, or modify, the first and second-level USs 3. Perform a completeness analysis of the third-level USs in regard to the second-level USs	Definition of USs in agile practices [2]
A3	T3	US specifications	1. Evaluate whether the third-level USs meet the degree of specification needed for product USs; if a higher degree of granularity is required, generate a fourth level of USs	Definition of user stories in agile practices [2]

Activity	Technique code	Technique	Step-by-step	Tools
			2. Use the priority diagram to specify the USs that are clear to both the stakeholders and the work team 3. Review the structure of each US, both at the level of syntax in its specification and its correct relationship with the dimensions of multimedia content, responsible design, and emotions 4. Make the necessary adjustments to the general map of alignment between USs and the IME 5. Define the priority of the USs in the last level vertically 6. Define the priority of the USs in the last level horizontally 7. For each US, specify a code, start and end dates, its dependency on the relationship with the lower-level USs that must be produced to complete it, its degree of completeness, its degree of development concerning its start and end date, its priority (vertical and horizontal) and its predominant influence on multimedia content, responsive design, or emotions	US generation guide [31]
A4	T4	Validation and testing of USs	1. Define the different scenarios needed to validate each US 2. Define a validation criterion for each of the identified scenarios, based on the Gherkin structure 3. Evaluate, discuss, and adjust the validation criteria with the participation of stakeholders 4. Evaluate the results obtained in the performance of tests, in contrast to the criteria	Validation criteria and satisfaction conditions [33]

To construct the general US alignment map (T1 technique), we use the general US map artefact for the MVMS illustrated in Figure 3, specified as a work product in practice (see Figure 1). This map allows the design team to conceive a set of epic USs that are directly aligned with the scope of the IME. According to the nomenclature used for the illustration, stories US1, US2, US3, …, USn are the set of epic USs in the MS. The second-level USs, identified as US1.1, US2.1 and US3.1, are produced with the aim of allowing the work team to analyse whether the completeness of the epic USs of the first level is achieved.

Finally, the USs associated with codes US1.1.1, US2.1.1, and US1.1.2 are subjected to a completeness analysis with the top-level USs. These third-level USs are considered candidates for production, meaning the designer can move on to the next

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stage of MS production. The third-level USs that are shown enclosed in a red box with red numbering suggest a prioritisation for possible implementation.

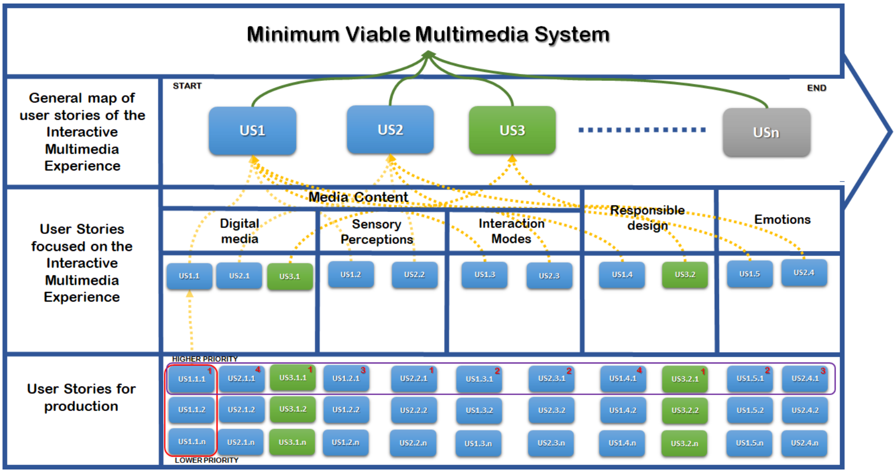

Fig. 3. General map of alignment between USs and the IME.

To facilitate the map construction process, a US specification card was designed for the MVMS. This card is illustrated in Figures 4 and 5, which show the front and back of the card, respectively. This artefact is also specified as a work product in practice (see Figure 1). The design of these artefacts includes several information elements, which are consistent with the design factors suggested by the general US alignment map. These data elements are shown in Table 5 below.

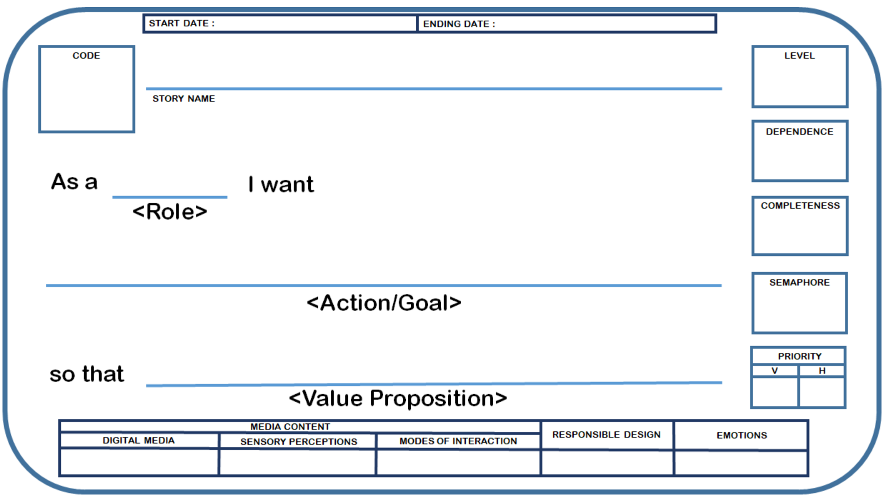

Fig. 4. The front of the US card.

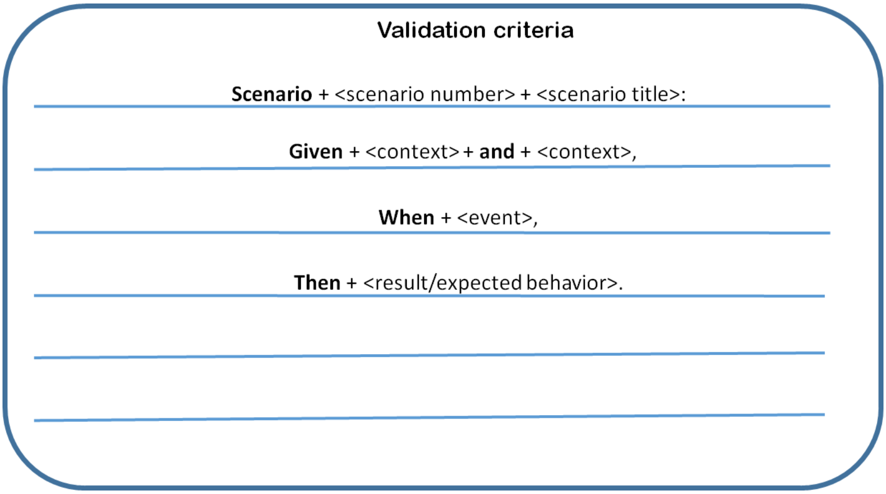

Fig. 5. The back of the US card.

Table 5. Informative elements contained in the US cards

Element	Description
Code	Represents a unique identifier for the US throughout the development of the MS
Start/end dates	Dates on which the implementation of the US starts and should finish
Name of the story	Name assigned to allow the work team to establish an associative relationship with the content of the story and its relationship with the IME
Level	Specifies the level with which the US is associated, according to the general US map for the IME
Dependency	Relationship of association between one US and a higher-level US in the overall user story map for the IME
Completeness	Degree of implementation of the US, which can be represented as a percentage of its implementation
Traffic light	Visual representation that relates the degree of completeness of the US concerning its degree of completion as planned for the project. Green indicates that the degree of implementation of the US is within the limits agreed with stakeholders; orange indicates a gap between what was agreed with stakeholders and the degree of US implementation; red is represents a very important gap between the implementation and what was agreed with the stakeholders, and the work team and the stakeholders must assess the reasons why this situation has arisen
Priority	Specifies the priority of the user story, both vertically (V), which is reflected in the last index of its coding, and horizontally (H), as shown by a number in red, for each line of USs arranged at the US level for production, in the general map of alignment of user experiences with the IME (see Figure 3).
US statement	Corresponds to the statement of the US, based on the following structure: As <Role>+I need+<Action/Objective>+for+<Value

Element	Description
Multimedia content/responsible design/emotions	Proposition> Indicates the alignment between the US and the dimensions that characterise the MS

3.2 Research Methodology for Case Study

To guide the process of designing the practice as a solution artefact, this study relies on the principles of design science research methodology [34]. This methodology suggests a set of guidelines for its application [9], which are discussed in this paper, as follows: (i) the basis of a relevant problem (in this case, the limitation of the current methodologies for the development of MSs oriented towards practices based on agile approaches); (ii) a practice for the specification of USs for the design of an MS as a solution artefact; (iii) an evaluation of the design of the practice for the conception of the MS; and (iv) a description of the contribution and limitations observed as a result of an evaluation of the practice for the specification of USs in the design of MSs.

Based on the above, the following hypothesis was defined based on the description of the practice, as a validation mechanism for the case study: *The application of the proposed practice for US specification contributes to a reduction in the number of problems associated with vagueness and inadequacy in the US generation process for an MVMS.*

This hypothesis was drawn up based on results reported in previous studies [35] [36] related to ambiguity problems in USs, such as vagueness, inconsistency, insufficiency, and duplicity [7]. In this case, our study aims to assess the contribution of the proposed practice for US specification for an MVMS to the specific problems of vagueness and insufficiency. These problems are of interest since they prevent an accurate interpretation of the expected structure and behaviour of the system; we therefore want to prove that the activities, techniques, and tools that make up this practice are effective in terms of generating the concrete USs for an MVMS.

3.3 Context of the Problem

To carry out an analysis of the potential contribution of the proposed practice for MSUS to reducing vagueness and insufficiency as problems of ambiguity in specification, a research project called Coco-Shapes was carried out to explore the development of an IME in school contexts. This project arose from the need to teach a second language (in this case, English) to kindergarten and transition children between four and five years of age in a private school in the city of Cali, Colombia, which is committed to an educational strategy of bilingualism for people with limited resources [37]. The school is located in the Siloé neighbourhood, one of the most socially and economically vulnerable neighbourhoods in the city [38]. One of the problems addressed by this initiative is the difficulty faced by the Colombian population in accessing the learning of a second language in public and private schools in less prosperous communities [39]. An MS was therefore developed based on a MVP [17] related to an IME, based on gamification techniques [40]. Currently, the school has a population of about 140 students between kindergarten and fifth grade.

Coco-Shapes includes activities related to the themes of colours, shapes, and counting. In addition, the solution includes a physical object (with buttons and geometric shapes) and digital resources that are displayed on a tablet, as shown in Figure 6. In activities involving geometric figures, children must insert the corresponding figures into the physical object, whereas in the colour activities, students must press the coloured buttons that are also found on the physical object. Finally, in the counting activities, children must select the correct option on the screen. These activities are divided based on grade levels, and there are three levels of difficulty, which strengthen different abilities of the student.

Fig. 6. The Coco-Shapes object and its components.

3.4 Formation of Work Teams

Over a period of one month, 10 professionals (age range between 25 and 30 years) with average experience of 4 years MS development and two tutors (leaders with PhD degrees and senior experience in MS development) implemented the practice for the US specification of Coco-Shapes.

Two homogeneous groups were formed: a control group, and an experimental group. Each was composed of five professionals, and remained unchanged throughout the process. Each group developed the specification of the US according to the needs of the Coco-Shapes MS under the guidance of a tutor; the control group followed the traditional approach defined by SCRUM, while the experimental group used the proposed practice for US specification of an MVMS.

3.5 Validation Mechanisms

Table 6 lists a set of factors that were defined to facilitate the analysis and evaluation of the hypothesis. These factors correspond to those studied during validation, where

F1, F2, and F3 correspond to problems of vagueness, and F4 and F5 correspond to insufficiency detected in the US [7].

Table 6. Factors considered in the analysis of the case study

Identifier	Analysis factors
F1	Number of vagueness issues related to the structure of the US
F2	Number of vagueness problems related to unclear words
F3	Number of vagueness problems related to semantics
F4	Number of incomplete USs
F5	Number of unattended requirements of the solution

The first factor (F1) refers to the number of USs that do not comply with the basic structure, which should include three elements: the role, the action/objective, and the value proposition. The second (F2) refers to the use of words in the US whose meaning is not clear to stakeholders, as they are technical business terms or terms that suggest subjectivity in a US (such as ‘many’, ‘few’, ‘high’, ‘low’, ‘several’, ‘different’, etc.). The third factor (F3) refers to the absence or imprecision of a specific, meaningful scope, which results in an equivocal interpretation of the US. The fourth factor (F4) consists of the number of USs that omit details of the functionalities desired by the user. Finally, the fifth factor (F5) relates to the number of system requirements that are consistent with the scope of the solution but are not expressed by the US.

In the case study, the total set of USs produced by the work teams was considered in the analysis of the factors defined above. When each team had completed the US specification process, the coach for that team assumed the role of evaluator for each analysis factor.

4 Results of the Case Study

Before conducting the case study, the work teams collaboratively surveyed the stakeholders of the Coco-Shapes multimedia experience by interviewing the teachers and directors of the school. This process allowed them to determine the needs of the stakeholders (managers, teachers, and students), the learning objectives and the activities associated with each of them, the context of the use of the system, and the hardware components, software, and physical objects that made up the solution. The pre-production of Coco-Shapes allowed the value proposition of the systems to be identified and the scope of the MVMS to be defined, and enabled a series of high-fidelity prototypes of the multimedia experience to be produced. All of these are important inputs to the US specification. The following sections describe the process and the results achieved by the control and experimental groups.

4.1 Results from the Control Group

Process. The control group followed the traditional approach defined by SCRUM [32], which consisted of the following stages:

1. Identification of epics
2. Definition of the USs related to each epic
3. Specification of acceptance criteria for each US
4. Prioritisation of the USs

The work team implemented these stages over one month, under the supervision of a tutor, and obtained the results presented in Table 7. It is important to mention that during the course of this month, the work team carried out two iterations of analysis and adjustments to the USs, based on meetings with stakeholders.

Table 7. Overall results for the control group

Identifier	Analysis factors	Tutor's Observations
Epics	**10**	The epics were grouped based on the following elements: learning activities for kindergarten grade (3) and transition grade (3), teacher (2), physical object (1), and system control (1). The team wrote the epics and USs based on an analysis of information collected previously, such as stakeholder needs, learning objectives and activities, value proposition, high-fidelity IME prototypes, and the journey map. In this process, physical (Post-it notes) and digital (Google Jamboard) resources were used. The colours of the Post-it notes helped in representing the US groups.
US	**61**	The professional team maintained active and assertive communication with the school's stakeholders, and held a weekly one-hour meeting in which they asked questions about the details of the US acceptance criteria.

Problems identified by the control group. The tutor detected problems with vagueness in the written USs related to unclear words; for example, sample US18 included a word (underlined below) for which the meaning is not clear, and is subjective for the development team.

US18: As a <kindergarten student> I want < to fish <u>a series</u> of objects from a pool by pressing coloured buttons on the physical object>, which <helps me to identify colours in the English language>.

In addition, the US32 sample had inaccuracies in its scope, which may lead to misinterpretation of the US. From the fragments underlined below, it is not clear how many colours should be pressed and where the user should perform the action (tablet or physical object), and it is also difficult to identify the context in which the audio should be played.

US32: As a <transition student>, I want <to press colours for the main character to prepare cotton candy, while audio sets the scene for the activity> so that <I can learn the secondary colours resulting from the combination of the primary colours and their representation in English>.

Other USs omitted details of the desired functionalities in Coco-Shapes, as was the case for US41, since the user's action, the number of tables to include, and the specific data to be observed from each were not specified.

US41: As a <teacher>, I want <tables and texts that tell me the scores of my students for each activity> so that <I can get all the information on my students' scores>.

4.2 Results from the Experimental Group

Process. The experimentation group followed the practice activities for the specification of US in multimedia system design, in the following order:

1. Definition of epics associated with the MVMS value proposition and the EMI event flow, according to the scope of the solution.
2. Division of first-level epics based on the following elements: digital media, sensory perceptions, interaction modalities, responsible design, and emotions.
3. Division of the second-level epics into other specific USs that will be put into production by the development team.
4. Assignment of priorities to third-level USs.
5. Definition of a series of validation criteria for each third-level US.
6. Elaboration of the general map of US alignment with the IME.

The work team implemented these stages over a period of one month, under the supervision of a tutor, and obtained the results shown in Table 8. Similarly to the control group, the team conducted two iterations of analysis and adjustments to the US, based on the stakeholder meetings.

Table 8. Overall results for the experimental group

	Quantity	Tutor's Observations
First-level epics	**10**	The epics were grouped based on the following elements of the IME: system configuration, story character, physical object, colour identification, colour combinations, identification of geometric figures, association of geometric figures with real objects, counting from one to 10, counting from one to 20, and student progress.

	Quantity	Tutor's Observations
Second-level epics	**35**	The team used the Miro software tool[1] to divide the first-level epics into the following types: digital media, sensory perceptions, interaction modalities, responsible design, and emotions.
Third-level epics	**98**	The team of professionals maintained frequent communication with the school's stakeholders, holding at least one meeting per week where they raised questions to refine the US validation criteria.

Issues identified in the experimental group. The tutor detected vagueness problems in the written USs that were related to unclear words; for example, sample US4.1.1 included a word (underlined below) whose meaning is not clear, and is subjective for the development team. In addition, US5.1.3 refers to "a button", but it is not clear whether the button is shown on the tablet or forms part of the physical object.

US4.1.1: As a <student>, I want <the multimedia experience to include animations and eye-catching 2D images of Coco fishing for objects in a pool, a reproduction of the instructions and coloured buttons on the physical object that can be pressed> that will <help me to identify colours in the English language>.

US3.1.3: As a <student>, I want <a multimedia system that uses animations and 2D images to show Coco spinning a roulette with the names of the colours written on it, which stops when I press a button, and the name of the colour is stated via audio> so that <I can easily recognise the colours presented on the display device>.

US10.3.4 presented a problem of insufficiency, as it did not include enough detail about the specific data that the teacher expects to see in the report.

US10.3.4: As a <teacher>, I want <the multimedia system to allow me, via a touch screen, to see the score for each student> so that <I can manage all of my students' information>.

4.3 Overall Results

Table 9 presents the results for each analysis factor considered by the control and experimental groups, which were evaluated by the respective tutor. The analysis factors were applied to the total number of USs specified by each group. The ratio shown in the table was calculated by dividing the number of problems for each factor by the total number of USs specified by each group.

[1] URL: https://miro.com/es/

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Table 9. Comparison of analysis factors

Factor	Analysis factor	Type	Control group	Ratio	Experimental group	Ratio
F1	Number of vagueness issues related to the structure of the US	Epic	1	0.1	0	0
		US	37	0.60655738	0	0
F2	Number of vagueness issues related to unclear words	Epic	0	0	0	0
		US	5	0.08196721	10	0.10204082
F3	Number of vagueness issues related to semantics	Epic	0	0	0	0
		US	5	0.08196721	4	0.040816327
F4	Number of incomplete USs	Epic	0	0	0	0
		US	3	0.04918033	4	0.040816327
F5	Number of unattended requirements of the solution	Epic	1	0.1	0	0
		US	41	0.67213115	2	0.02040816

Figure 7 presents a comparison of the average overall ratios for the control and experimental groups, considering the overall results in the factors under study. It can be seen that there is a reduction of approximately 10% in the number of ambiguity problems in the set of USs formulated using the proposed MSUS practice.

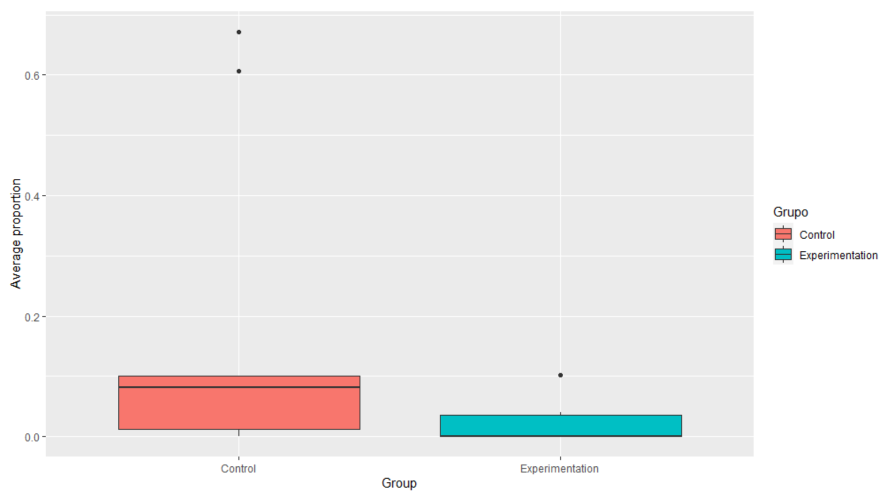

Fig. 7. Comparison of the average ratios between groups.

Figure 8 presents a comparison between the average ratios of the control and experimental groups for the factors related to vagueness and inadequacy, as explained in Table 6 in Section 3.5. It can be seen that the proposed MSUS practice contributed

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significantly to a reduction in the number of US ambiguities related to insufficiency factors and, to a lesser extent, to those related to vagueness.

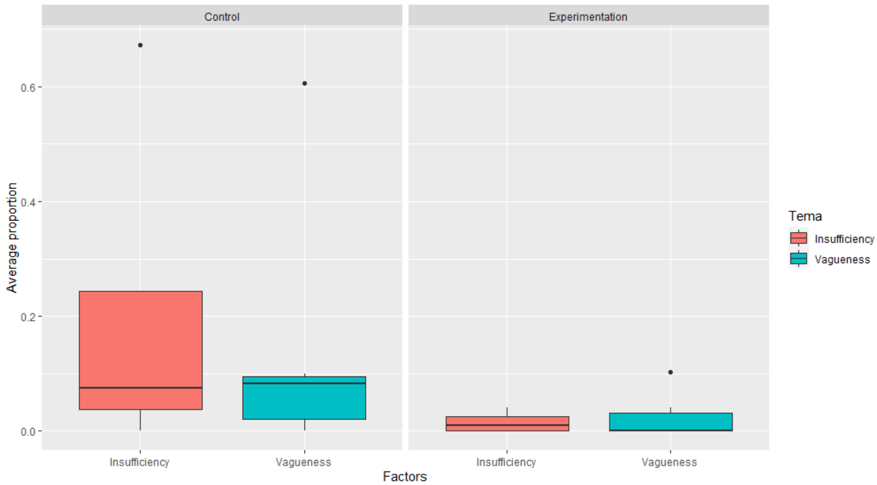

Fig. 8. Comparison of factors between the control and experimentation groups.

5 Discussion of Results

From the general results for the analysis factors (see Figure 7), we see that the average of the overall proportion between the control and experimental groups shows that there are differences between each group with a significance of 10%. This indicates that the experimental group obtained a lower number of ambiguity problems in the set of USs formulated using the proposed MSUS practice. This can be considered a positive result, since the professionals who were part of the control and experimental groups were people with experience in the development of MSUS.

Regarding the formulation of the epics, the results in Table 9 for the control and experimental groups could be interpreted as not having a major impact on the specification of the MVMS. However, this interpretation can be seen to be inaccurate when the specification scope of the epics is compared with the scope of the MVMS, because, since it is epic, it implies that the set of USs associated with the IME was not considered. In this case, the control group did not consider a key element of the IME in the form of the main character, Coco, the spectacled bear. Since this IME is aimed at children, this character plays an important role in the child's interactive relationship with the system, and is therefore a crucial element. The absence of the epic had a noticeable impact on the US comparison concerning the IME scope.

Each analysis factor considered in the formulation of the US is discussed below.

For factor F1, a difference was found between the control group and the experimental group. The tutor of the control group detected that the professionals analysed the inputs before specifying the USs, and focused strictly on the actions performed by the user in the system, i.e., the moments of interaction between the user and the system. Meanwhile, the experimental group, in addition to specifying USs involving user actions, also identified other USs associated with multimedia content objectives, responsible design, and emotions, thanks to the T3 technique included in the proposed MSUS practice.

For factor F2, we note that since the experimental group identified a greater number of USs, more vagueness problems were found related to unclear words. The tutor of the experimental group identified that when writing USs related to multimedia content, responsible design, and emotions, the professionals tended to use subjective words to specify the characteristics of the system in terms of its design, such as ‘eye-catching interface’, ‘funny bear’, and ‘funny music’.

A significant difference was observed for factor F3. This suggests an important contribution from the T3 technique, since it promotes the revision of the degree of specification of the US, as well as its correct structure. The tutor of the experimental group recognised that the time invested in carrying out the steps of the technique was extensive, but completing all the steps contributed significantly to achieving a greater degree of certainty regarding the vagueness factor under study.

For factor F4, it is evident that the difference between the ratios is small. Although the tutors emphasised the rigorous work done by the teams in terms of active communication with the stakeholders, it was noted that the experimental group was able to do a better job thanks to the information given on the front of the cards to assist in writing the USs. The "dependency" and "completeness" fields were important in reducing the number of incomplete USs, as they allowed the work team to maintain better traceability of USs related to the same action or objective.

Finally, for factor F5, we observed an interesting difference between the control group and the experimental group. The tutor of the experimental group highlighted the following aspects of the process:

- The use of first-level epics allowed the experimentation group to write a set of epics that ensured the value proposition and scope of the IME of MVMS for the different roles involved in the use of Coco-Shapes.
- At the second level, the experimentation group defined a set of epics with a higher degree of concreteness than the previous ones, which were classified based on the structural components of the IME: digital media, sensory perceptions, interaction modalities, responsible design, and emotions.
- At the third level, the experimentation group was able to write a set of USs for subsequent implementation with a high degree of concreteness. The use of the overall US alignment map made it possible to have a global view of how the USs were aligned with the second-level epics and were organised by the team according to their priority.

Overall, the results for the ambiguity factors are promising in terms of the contribution of the proposed MSUS practice to reducing the problems of vagueness and insufficiency when writing USs. The results of our evaluation of the ambiguity factors provide evidence that a satisfactory degree of compliance with the hypothesis raised by this study was achieved (see Section 3.2) when the work carried out by the control and experimental groups in the specification of USs was contrasted.

Finally, comments derived from the application of the practice by members of the experimental team are presented, indicating an optimistic outlook regarding the utilization of the practice.

- *The activities within the specification route are deemed highly beneficial for transitioning to the solution's implementation phase. The template established for the user story and validation criteria, particularly the scenarios, provide precise guidance on implementing the user stories.*
- *The route recommends creating a user story alignment map, serving as a crucial foundation for planning the implementation. This includes prioritizing the user stories.*
- *Decomposing user stories across three levels proved to be a complex experience; however, it is noteworthy that the third level of user stories attained a commendable degree of precision.*
- *As a team, experienced a sense of calm during user story specification process, as each prescribed activity provided us with a set of specific techniques for execution.*

6 Conclusions and Future Work

Based on the discussion of results presented in this study, it can be concluded that the proposed MSUS practice has shown its effectiveness in terms of its application, and can contribute to a reduction in the number of ambiguity problems in the specification of USs where the scope of the IME of MVMS governs the specification process carried out by a work team. These results motivate us to apply the MSUS practice in other contexts of use, and to study the overall impact on the solution design process via variables such as the time invested in the specification of USs, the number of iterations, the user's level of experience and work style, and others that fall outside the scope of this research.

In addition to the above, there is an opportunity to evaluate the potential contribution of the proposed MSUS practice to the development of MS by teams whose professionals have a basic level of experience.

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