Proposal to Conceive Multimedia Systems from a Value Creation Perspective and a Collaborative Work Routes Approach

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Abstract. Methodologies for the development of interactive multimedia systems traditionally apply the practices and lifecycles of user-centred design in conjunction with usability and accessibility practices guided by software engineering process models. This work contributes to the conception of multimedia systems through a new way of working using a set of work routes encouraging collaborative work. This new approach to conceive multimedia systems is centred on value creation and value-sensitive design, through a formal characterisation based on theoretical foundations. The results obtained from an evaluation of this definition, using a case study in an academic context, show that our scheme facilitates the conception and planning of factors such as the interactive multimedia experience and the responsible design of the solution.

Keywords: User-centered design, Multimedia system conception, collaborative work for multimedia system design.

1. Introduction

The development of interactive systems (IS) and multimedia systems (MS) has traditionally been supported by the discipline of human–computer interaction (HCI) and the methods of user-centred design (UCD) and interaction design (ID) [1]. These methods of UCD are based on the lifecycle, which forms part of the models of the software engineering process [2].

The different methodologies for the development of IS and MS are studied using a systematic review method [3], and an analysis phase is proposed in which both the work team and the stakeholders begin a process of understanding the interests, needs, and opportunities that motivate their development. At UCD, this process suggests that it must be maintained throughout the system development life cycle. However, the

existing methodologies have generated few results related to specifying a phase in which the suggested practices lead to collaborative work between stakeholders, using creative and ideation processes for the conception of MSs. Likewise, there are few works that have addressed the foundation and characterisation of MS, and these works are not conceptually correlated with the studied methodologies.

This work does not discuss the need to implement a design process for an IS, an MS or a hardware–software architecture model of an IS or MS, according to the specification of the requirements of the stakeholders [4]. Instead, we respond to a gap that can be identified in the conception of an MS, centred on value creation to stakeholders.

Our work is based on the fundamentals and methodologies of MS development, design thinking, ethical aspects from the value-sensitive design (VSD) practices [5], taking into account the interactive multimedia experience (IME) as the centre of value creation by the MS in any use context. However, the proposal is not focused on aspects of software design, but rather on the creative conception of multimedia systems, with the potential to be applied to the design of generic solutions where the multimedia plays a key role in the product design.

Likewise, the proposal for the conception of multimedia systems does not replace the traditional process for the conception of software. On the contrary, it is presented as a resource that can be taken into account, in solutions where multimedia plays a key role in the value creation for the stakeholders.

The paper contains six sections. Section 2 presents background information on the different definitions and existing methodologies for the development of an MS. Section 3 proposes a new approach to the definition of an MS that is focused on value creation, proposing a formalisation for the characterisation of the MS. Section 4 offers a methodological approach to the conception of MSs that is theoretically based on this characterisation. Section 5 presents a case study, and specifies the hypothesis and research method used in the practical application of the proposal. Section 6 presents the results obtained from the case study. Finally, section 7 contains a discussion and suggestions for future work in this area.

2. Background

2.1 Multimedia System as a concept

The use of the term ‘multimedia’ dates back to the mid-1960s, when music writer and artist Bobb Goldsteinn coined it for the presentation of his show "LightWorks at L'Oursin" in New York. This term referred to the technical nature of his experience, which was based on light effects synchronised manually with images and sounds [6]. The term MS was subsequently used by authors such as Smith et al. [7], who did not give a specific definition of the concept but used it in regard to academic practices

incorporating systems that enabled the use of new (at the time) media such as audio or video to support teaching–learning processes within a classroom.

Later, and in the 1980s, the term MS was reused by several authors such as Mock [8] to refer to different configurations of entertainment systems for home use; Calnan [9], who described it as a system based on hardware–software architectures that enables the deployment of digital media; and other authors such as Mether and Bratton [10], who continued to approach the concept along the same lines as Smith et al., in relation to the educational context of teaching–learning.

However, the relationship between the concepts of MS and interactivity occurred initially in the discussions proposed by Shavelson and Salomon in field of educational research [11],[12], who concluded that the use of information technologies in the media must play an important role, through the interactivity between the user and the content.

The concept of MS more closely approaches the context of computational sciences, through proposals such as that of Pina [13], who defines MS as "*interactive systems with multiple codes*". This author states that "*[t]he integration of different types of information supported by different codes*" consists of the key factor of this type of system, and concludes that the term 'interactive MS' is redundant.

Recent definitions have focused on the concept of an MS in the context of computer science, including that of Steinmetz and Nahrstedt [14], who describe the importance of technological mediation in the capture, processing and presentation of digital information to the user, and the ability to support multiple forms of digital media. Cuevas et al. [15] offer a definition that remains focused on computer science, but which specifies the different types of digital media that can be managed by an MS.

The approaches of Steinmetz and Cuevas in regard to the definition of an MS are integrated in the definitions set forth by Sampaio et al. [16] and Alkhalifa [17], who define it as "*any type of electronic computer-based system*" with the ability to present information via different forms of digital media (which may include text, sound, computer graphics, video and animations), and to use its functions for storage, search, recovery and data processing.

In view of these definitions of an MS, and particularly in terms of its description as a technology-mediated system that manages digital media, there is a gap identified in the literature, and hence a need to define a set of attributes that are associated with value creation by an MS for stakeholders.

2.2 Methodologies related to the development of Multimedia Systems

There is a common trend in which the different methodologies for the development of MS are mainly focused on traditional practices of software engineering, systems engineering and their adaptation to UCD practices. This trend can be observed in proposals such as that of Cuevas et al. [15], who adapt an iterative and incremental process model of software engineering to UCD practices.

Other methodologies based on software engineering and UCD for the development of software-based MulSeMedia (multiple sensorial media) systems use the model-driven architecture; for example, the scheme proposed in [18] is based on a form of digital TV

that offers other sensory perceptions in addition to audiovisual, such as wind, vibration and light. Likewise, the MPIu+a methodology for the development of IS [19] defines a set of practices that are focused on usability and accessibility, and are guided along an iterative and incremental lifecycle for software development.

Vilimek's proposal [20] for the development of multimodal systems through the application of practices based on software engineering, which involves eight phases, allows the work team to define the set of interaction modalities and their integration with the system's user interface, through a set of practices based on UCD.

Other schemes use approaches originally based on systems engineering, such as that of Leonard [21] for the development of MSs for flight entertainment. Boy [4] adapted the traditional V model of systems engineering (with practices based on human–systems integration) for the development of different types of solutions, including multimedia systems that were designed to fulfil specific functions as simulators in a human-in-the-loop-system as part of the process of development of interactive mission-critical systems in the aerospace industry.

The methodologies for the development of MSs that have been studied, do not specify a particular type of process, phase, method or practice that allow a previous formal conception of the system. Even adaptations of the UCD methodology, in which the design process is always focused on the user's needs, do not specify a guide for the conception of the solution, meaning that the conception of the MS is dependent on the experience and knowledge of the members of the team.

With a focus on value-sensitive design (VSD) practices, Friedman et al. [22] specified a set of 17 methods for the application of VSD practices. Many of these methods are drawn from other disciplines, for example the social sciences and fields such as anthropology, moral and social psychology. One of these methods focuses on an analysis of values in technology, and due to its versatility offers ample scope for adaptation to different contexts in which the solution requires the mediation of information technologies, using 'envisioning cards' [23].

Some recent experiments have used the envisioning cards method, such as that of Ballard et al. [24] in which a card game named Judgment Call allows the player to design interactive systems from an ethical point of view. These systems are based on artificial intelligence techniques applied to facial recognition, based on fictional scenarios. VSD methods such as envisioning cards offer a set of generic tools for the analysis of values in terms of the ethical and moral aspects of technology, and do not necessarily specify a workflow to guide the production team towards the specific conception of a solution. Projects such as Judgment Call also adapt the application of the method to a specific need for VSD analysis, without guiding the conception of a general solution.

The references analysed and described in this background review form part of the previous research carried out in [3], and offer us an opportunity to work around a conception of MS that is centred on providing value to stakeholders. VSD practices play an essential role in meeting the needs, expectations, interests, and motivations of the stakeholders from an ethical and moral perspective, thus driving the development of MS in a responsible way. This study contributes to closing this gap, and addresses the design of MS centred on value creation.

3. Definition of a Multimedia System

Based on the above, we can show that the current definitions of an MS are focused on a description of the hardware–software technologies, such as information processing, and the searching, storage, retrieval and deployment of digital information. However, none of these definitions is concerned with discerning the value contribution of an MS, which motivates interested parties to make a series of efforts towards the development of the solution. The above observation is based on the premise that the production of any type of MS fulfils a wider purpose than simply its conception, design, and technological development. Norman [25] calls for reflection on the definition of an MS that is centred on other attributes and is focused on value creation for stakeholders.

To meet the need for a new definition of MS that is focused on the value it creates, this work follows two guiding criteria:

C1: The potential for value creation that an MS can offer to stakeholders is mainly centred on the deployment of the IME. The storytelling, digital media, sensory perceptions, interaction modalities and all forms of technological mediation must be designed to create an IME that meets (and ideally exceeds) the needs and expectations of interested parties, especially the user.

C2: To ensure the creation of value from an IME, its conception must include the ethics and the responsible design that takes into account the interests, needs, and expectations of the interested parties. These stakeholders are not only viewed as a collective, but also as specific actors influenced by the potential differences and value tensions that may arise between the representative instances of these interested parties.

Based on the two criteria described above, and the theoretical reference for HCI, ethics, and responsible design, the following definition of a multimedia system can be proposed: *A system that allows for value creation for interested parties through the deployment of an interactive multimedia experience, 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*.

This definition emphasises the following:

1) Value is created for the stakeholders due to the MS.
2) The creation of value by the MS is focused on the generation and deployment of an IME, as a consideration that differentiates the MS from other ISs.
3) The proposed value creation arising from the generation and deployment of an IME must be aligned with principles that are sensitive to human values as ethics and responsible design.
4) Stakeholders (such as customers and sponsors) in the development of the MS will be able to achieve value creation as a result of the generation and deployment of a IME if it meets the interests, needs, and expectations of users.
5) Finally, users will be able to perceive the IME via the stimulation of a set of sensory perceptions (auditory, visual, olfactory, gustatory, haptic, etc.), as well as through interaction with digital media resources that can only be made "tangible" by a hardware/software system.

Different authors have used ontologies such as Zachman from Enterprise Architecture (EA), as a taxonomic tool applied to modelling software based solutions

[26], [27]. These works are conceptually consistent with the theoretical foundations of the SEBoK guide [28], about the contribution of EA frameworks, to generate holistic views for information systems modelling. Following these theoretical principles, and because our definition for MS is centred in value-creation, we used the Archimate modelling language for EA [29], to represent a scalable model of value creation for MS, through and adapted motivation view of Archimate.

Fig.1 represents the definition for MS from a value creation perspective, using an EA motivation view, specifying the goals, stakeholders, principles high-level requirements, and restriction, influencing the value creation from a MS. For the ethics and responsible design approach, we are assuming the VSD theoretical approach as a valuable and mature reference for our proposal.

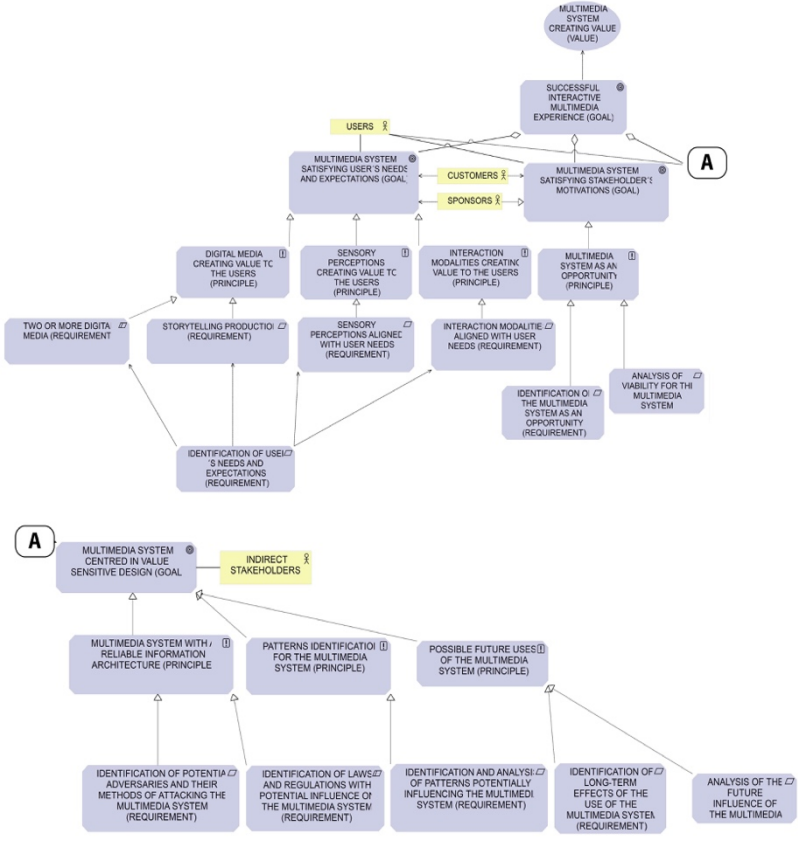

Fig 1. Motivational view of the characterisation for the definition of multimedia system.

The modelling for the definition of the MS using the motivational view of EA, contributes to the collaborative work of the teams, offering a common and unified view, about the main attributes involved in the value creation from a MS.

To achieve the goals defined by the MS definition (shown in Fig. 1), which are related to enabling the creation of value via an IME, we established a set of efforts to be

produced and abstracted through a set of processes. We also defined a logical sequencing for how the MS characterisation should be applied. To carry out high-level modelling of the processes of MS characterisation (shown in Fig. 2), we used the graphical notation language of the EA standard, Archimate, and more specifically a process view.

At the highest level of abstraction in Fig. 2, there is a triggering relationship between the multimedia system declaration process and the other processes of the user-centred design of the interactive multimedia experience, and the responsible design of the multimedia system.

At a more concrete view, each of the processes described in Fig. 2 contains a set of work routes (workflows), process activities, and techniques for conceiving an MS focused on value creation. The details of the work routes, process activities, and techniques are discussed in Section IV.

PR1: Process for declaring the mission of the MS, which is related to the dimension of value creation for the business objectives that are committed to the development of the MS. This contains the activities and techniques that allow for the identification of the business opportunity, the feasibility of developing the MS, its potential stakeholders and their needs and motivations.

PR2: Process for designing a user-centred IME, which is directly related to the dimension of value creation for the user of the MS. This defines a set of activities and techniques that are related to the conception and design of the IME, based on a storytelling definition.

PR3: Process for the responsible design of the MS, related to the dimension of value creation from the responsible design of the solution. This contains the activities and techniques that guide the responsible design, and focuses on the adaptation of VSD practices for the conception of the MS.

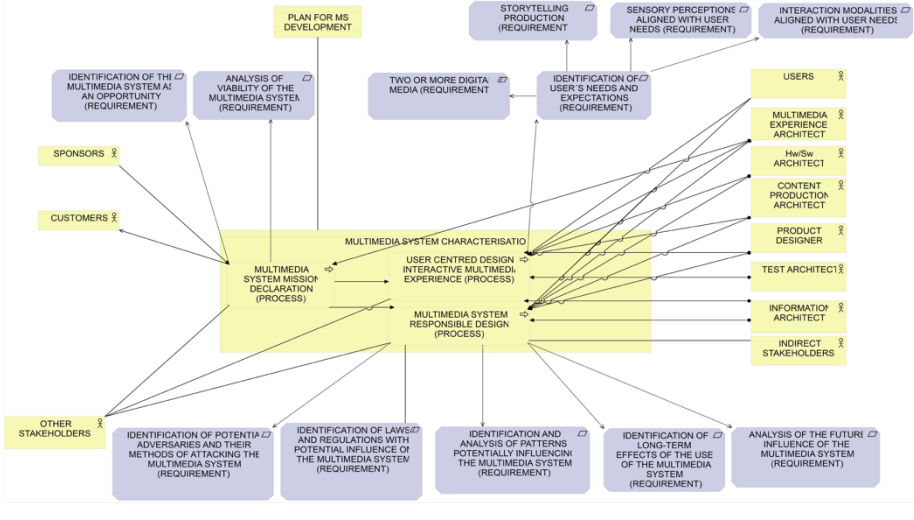

Fig 2. Processes view for the characterisation of the multimedia system.

Fig. 2 shows the triggering interrelation and workflow of the processes, lead to a work product in the form of a plan for MS development. Following the definition from TOGAF ADM for EA [30], the process defines a sequence of activities in order to develop its contents. Likewise, the meaning from the Software Engineering discipline, explains the process as a coherent set of activities for software production [2]. Considering the definition from both referents, in the next section, we are presenting the set of activities and their relationship, that composing the processes specifically for the characterisation of MS.

4. Multimedia System Conception

To facilitate the collaborative work, the set of activities of the processes for the characterisation for MS are grouped in a set of four work routes. Each work route fulfils an objective in the conception of the MS. The graphic representation of these routes is an original proposal for multimedia systems based on the design thinking work approaches suggested by Lewrick [31] as a visual representation for the common understanding of the work to do. In addition, the workflow given by the routes is a suggestion for help with the collaborative work for conceiving multimedia systems and not a recipe that must be followed verbatim.

The main purpose of conceiving an MS is to enrich the phase preceding the analysis of requirements. This enables a better understanding of the stakeholders' motivations, interests and needs, the potential for value creation and the feasibility of production, and to conceive an IME that can best fulfil and exceed the stakeholders' expectations. Likewise, a better understanding of the stakeholders' needs is reached through the use and adaptation of the VSD approach. The scope of the VSD practices in the MS conception includes the identification of indirect stakeholders in the MS, specification of value tensions between the MS stakeholders, and detection of any possible uses for the MS that differ from those initially conceived by the system designers, since these may allow for nefarious actions. The name and objective of the four routes is:

1) The **Genesis route** aims to recognise the (direct and indirect) stakeholders and the opportunities that identify customers and sponsors, motivating the development of the MS.
2) The **Creativity route** defines the basis of the story and the narrative universe in which the IME will be produced. The team determine the most suitable digital media, sensory perceptions, and interaction modalities, taking into account the emotions that the team wants to stimulate in users.
3) The **Responsible Design route** guides the team to identify value tensions between (direct and indirect) stakeholders, possible uses for the MS other than those initially conceived by systems designers, and policies and regulations that may influence or condition its design, among other VSD considerations.
4) The **Assurance route** allows for an estimate of the possible risks that may arise from the development of the MS and the design of the IME, as well as the possible methods and resources that adversaries might use to attack the MS, and their motivations.

Each route provides a workflow, activities, techniques, and a RASCI (Responsible, Accountable, Support, Consulted, and Informed) stakeholder matrix allowing the work teams to carry out the conception of the MS, to facilitate the understanding and the collaborative work between the members of the work team. Table 1 shows the stakeholders potentially involved in the conception of the MS.

Table 1. Stakeholders involved in the conception of the MS.

Abbreviation	Stakeholder	Description
S	Sponsor	Responsible for communicating the initial motivation for developing the MS, as result of a set of business objectives or community needs.
U	Users	Stakeholders for whom the IME conception process has been carried out, including their interests, needs, and expectations.
C	Customers	Stakeholders who are financing development of the MS or purchasing the final product for use.
IS	Indirect stakeholders	Stakeholders who are indirectly influenced (positively or negatively) by the use of the MS within a company or community.
MEA	Multimedia Experience architect	Responsible for producing the view with the highest level of abstraction of the IME that the system will offer its customers and end users. Leads the work on the conception of the story, the narrative universe, each of the components involved throughout the user experience cycle, and the rules and mechanics governing the IME.
IA	Information architect	Responsible for the MS design in terms of the information architecture that is needed for the IME and which is used through the deployment of the multimedia content.
HSA	HW/SW architect	Responsible for conceiving the MS architecture view at the hardware/software level, and for estimating the components that will be needed in the system.
CPA	Content Production architect	Responsible for defining the architecture, the set of all digital media and their interrelations, taking into account the IME conception defined.
TA	Test architect	Responsible for designing the testing strategy for the MS and its IME, during its conception and in the subsequent production process, from the most abstract views (linked to the value creation of the conceived solution) to the most specific ones (related to the hardware/software components of the system).
OS	Other stakeholders	These are experts in the subject matter in the use context, and contribute to specific needs during the conception of the MS.
PD	Product designer	Responsible for producing the concepts for the development of the physical components of the MS, taking into account the specifications defined from the design of the IME.

Fig. 3 shows the Genesis route, which includes a total of 5 activities and 16 possible techniques (indicated by rectangles) for the collaborative work. Activities with a yellow border represent the starting points of the route workflows, while activities with a red border represent the end of a workflow iteration along the route. These activities in the Genesis route are mainly focused on the principles of the UCD [1] and the VSD for the identification of the indirect stakeholders [5].

For the specification of the activities in Fig.3, Table 2 summarises the relationships between the activities making up the Genesis route and the processes to which they belong. It also provides recommendations for the work teams on each of the stakeholders´ role in each activity, based on a RASCI matrix. Table 6, presents the

specification of all the techniques used in the four routes. The colours yellow, blue and pink in the routes, represents the processes PR1, PR2 and PR3, respectively.

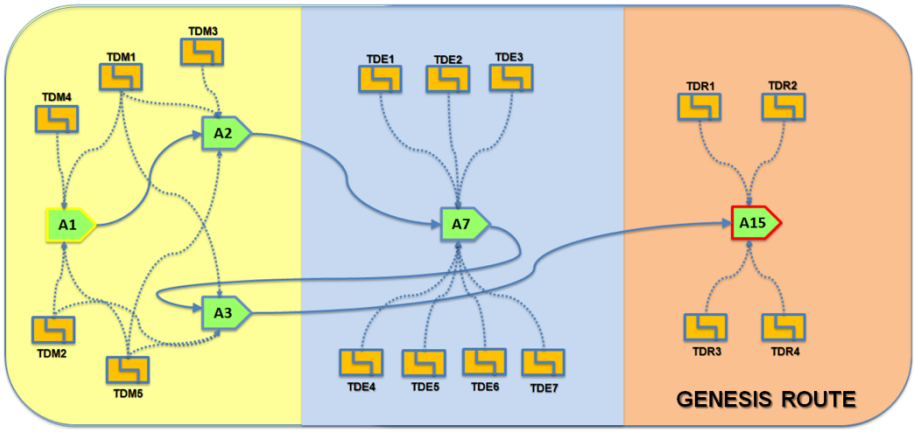

Fig 3. Genesis route for identification of stakeholders and recognition of opportunities for the multimedia system.

Table 2. Activities and RASCI Matrix for Genesis Route.

Activity code	Activities in the Genesis route	Process related to the activity
A1	Identify stakeholders involved in MS development: customers, sponsors, users, indirect stakeholders, and other stakeholders.	PR1
A2	Identify opportunities based on the motivations and needs of customers and sponsors with regard to the development of the MS.	PR1
A3	Carry out a contrast analysis of the needs of customers and sponsors vs. those of potential users of the MS.	PR1
A7	Identify and analyse users' interests, needs, and expectations, and the problems they wish to solve through the solution.	PR2
A15	Identify and classify potential indirect stakeholders in the development of the MS.	PR3

Activity	**Stakeholder**										
	S	**C**	**U**	**IS**	**MEA**	**IA**	**HSA**	**CPA**	**TA**	**OS**	**PD**
A1	A	C	C	C	R					C	
A2	A	C			R	C	C	C	C		
A3	A	C	C	C	R	I	I	I	I	C	I
A7	A	C	C		R	I	I	I	I	C	I
A15	I	C	C	C	A/R	I	I	I	I	C	

Following the conventions of Fig. 3, the Fig. 4, 5, and 6 illustrates the workflow, activities, and techniques in the Creativity route for the conception of the IME, the Responsible Design route, and the Assurance route, respectively. Tables 3, 4, and 5, specifies the activities and RASCI matrix for each route. In the Creative route and under the UCD approach, we adapt principles of the conception of multimedia experiences, based on general design thinking practices of Kumar [32] and UX storytelling practices [33].

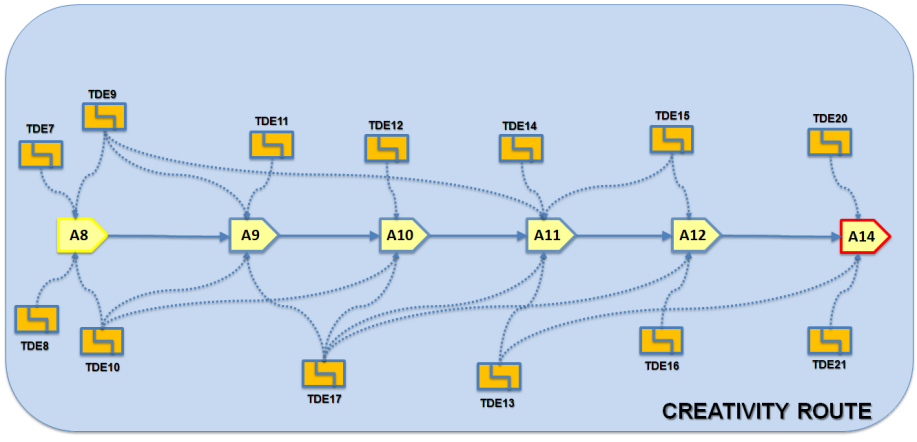

Fig. 4. Creativity route for the conception of the interactive multimedia experience.

Table 3. Activities and RASCI Matrix for Creativity Route.

Activity code	Activities in the Creativity route	Process related to the activity
A8	Conceive the structure and flow (narrative, temporal, events) of the story to be developed from the problem to be solved.	PR2
A9	Design the IME, based on the story and the identified problem(s).	PR2
A10	Analyse and define the types of digital media based on which the production of multimedia content will take place.	PR2
A11	Identify the different sources and processes of transforming information that occur because of the conceived IME.	PR2
A12	Conceive the sensory perceptions and interaction modalities required by the IME.	PR2
A14	Analyse and test the conceived IME.	PR2

Activity	Stakeholder										
	S	**C**	**U**	**IS**	**MEA**	**IA**	**HSA**	**CPA**	**TA**	**OS**	**PD**
A8	A	C	C	C	R	C	I	C	I	C	I
A9	A	C	C	C	R	C	I	C	I	C	I
A10	A	C	C	C	C	C	I	R	I	C	S
A11	A	C	C	C	C	R	I	I	I	C	I
A12	A	C	C		R	I	C	I	I		I
A14	A	C	C		C	C	C	C	R		C

For the Responsible Design route, we are taking into account of practices related to the VSD, specifically from a generic method as the envisioning cards proposed by Friedman and Hendry [23].

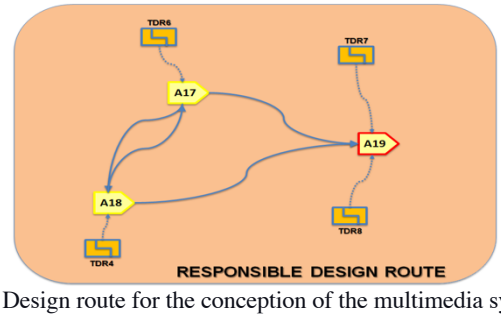

Fig. 5. Responsible Design route for the conception of the multimedia system.

Table 4. Activities and RASCI Matrix for Creativity Route.

Activity code	Activities in the Responsible Design route	Process related to the activity
A17	Analyse and identify the laws and regulations in force at global, national and regional levels, which may influence the design of the MS.	PR3
A18	Identify factors related to the indirect and long-term effects that may occur because of the use of the MS.	PR3
A19	Identify and classify patterns in contexts and the potential influence on behaviour due to the future use of the multimedia system.	PR3

Activity	Stakeholder										
	S	**C**	**U**	**IS**	**MEA**	**IA**	**HSA**	**CPA**	**TA**	**OS**	**PD**
A17	C	C			I	A/R	I	I	I	C	I
A18	I	C	C	C	A/R	I	I	I	I	C	
A19	I	I	C	C	A/R	I	S	I	I	C	I

The set of activities of the Assurance route are based on the generic principles of the IT Governance [34] and Project Management [35] focused on the analysis of viability, taking into account the VSD analysis, software and system engineering principles, and adapted for the multimedia system conception.

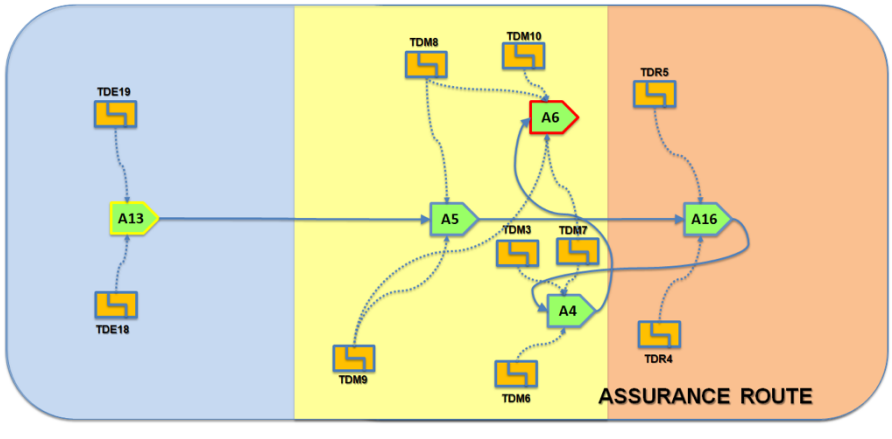

Fig. 6. Assurance route for the conception of the multimedia system.

Table 5. Activities and RASCI Matrix for Creativity Route.

Activity code	Activities in the Assurance route	Process related to the activity
A13	Make a preliminary estimation of the hardware/software architecture technologies and physical objects required to ensure a high-quality IME.	PR2
A4	Estimate and classify the risks associated with the development of the MS.	PR1
A5	Estimate the available and necessary resources for the development of the MS.	PR1
A6	Carry out a viability analysis for the development of the MS, and compare this with the innovation opportunities it generates for its clients and sponsors.	PR1
A16	Analyse and identify the impact of the motivations, resources, and methods	PR3

of potential adversaries that may decide to attack the MS.

Activity	Stakeholder										
	S	**C**	**U**	**IS**	**MEA**	**IA**	**HSA**	**CPA**	**TA**	**OS**	**PD**
A13	A	C	C		C	I	R	I	I		S
A4	A	I			R	S	S	S		C	S
A5	A	I			R	S	S	S	S	C	S
A6	A	C			R	I	I	I	I	C	I
A16	I	C	C	C	I	A/R	I	I	I	C	

Table 6. Techniques adapted for the conception of the multimedia system.

Technique Code	Technique name	Practices and disciplines that describe the origin of the technique
TDM1	Trend analysis	
TDM2	Convergence mapping	Design thinking [32]
TDM3	SWOT analysis	
TDM4	Identification of stakeholders	Design thinking [31]
TDM5	Value analysis	IT governance [34]
TDM6	Risk breakdown and analysis associated with MS development	
TDM7	Analysis for risk identification	Project management [35]
TDM8	Analogue resource identification	
TDM9	Ascending identification of resources	
TDM10	Canvas creation	Design thinking [31]
TDE1	Ethnographic analysis	Ethnographic techniques [36]
TDE2	Interviews with stakeholders	Human-centred design [37]
TDE3	Observation and analysis of the cognitive, social, cultural, emotional and physical aspects of human beings	Design thinking [32]
TDE4	User/customer process mapping	
TDE5	Experience simulation	User experience (UX) storytelling [33]
TDE6	Database of user observations	Design thinking [32]
TDE7	Video as support for ethnography	
TDE8	Definition of personas	Design thinking [31]
TDE9	Production of metaphors and analogies	UX storytelling [33]
TDE10	Storyboard creation	
TDE11	Mapping of compelling experiences	Design thinking [31]
TDE12	Matrix for the preliminary definition of the type of digital media	Design thinking [32]
TDE13	Classification of information for the multimedia experience	Information architecture [38]
TDE14	Design for content and information structure	
TDE15	Wireframe creation	
TDE16	Asymmetric grouping matrix between sensory perceptions, interaction modalities and digital media	Design thinking [32]
TDE17	Creation of the journey map for the multimedia experience	UX storytelling [33]
TDE18	Analysis and preliminary definition of software architecture technologies	Software engineering [2]; systems engineering [39]; product design [40]
TDE19	Analysis and preliminary definition of architecture hardware technologies and physical objects	
TDE20	Prototypes production of user behaviour against the multimedia experience	Design thinking [31]
TDE21	Concept prototypes	
TDR1	Identification of indirect stakeholders	Value-sensitive design [5]

Technique Code	Technique name	Practices and disciplines that describe the origin of the technique
TDR2	Identification of value tensions	Value-sensitive design [22]
TDR3	Relationships that transform	
TDR4	Non-directed use	
TDR5	Analysis of the motivations and resources of adversaries and the impact of the system on people	
TDR6	Identification of policies and regulations	
TDR7	Analysis of user responses	Design thinking [32]
TDR8	Identification of patterns	

Each technique showed in Table 6 have a set of steps, bringing the team a guideline to complete the collaborative work needed to achieve the objective of each technique. As example, Fig. 7 show the recommended guidelines for the TDE17.

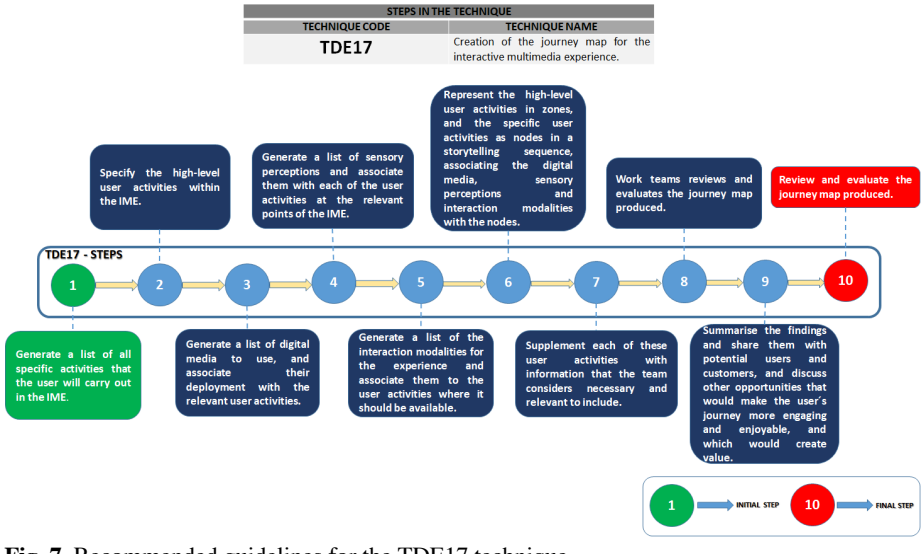

Fig. 7. Recommended guidelines for the TDE17 technique.

The expected outcomes of the work done in the routes for the conception of the MS are a set of work products relating to the implementation of the routes by the teams. Work products are classified into three groups: i) specifications for the MS mission, ii) specifications for the user-centred IME, and iii) specifications for the responsible design of the MS. The overall set of work products defines the plan for development of the MS (see Fig. 2). The work products form the basis of subsequent activities related to the pre-production and production of the MS, and provide a guide for the design-to-development handoff engineering process.

5. Case study

In this section, we focus on analysing the evidence obtained from applying the routes for the conception of the MS, based on the following hypothesis:

H1. *The members of the team can achieve high levels of clarity and criteria unification in the work involved in the conception of the MS due to the use of the work routes*.

Both, the clarity and criteria unification in the work involved for the conception of the MS, are key elements contributing to the collaborative work.

The research methodology of the case study was based on the recommended guidelines defined by principles of the design science research methodology [41], and the qualitative research methods adapted for software engineering [42].

Over a four-month period, 18 practitioners with experience as junior developers in MS and a tutor with PhD studies and senior experience in the evaluation of usability and interactive systems development worked on four different projects related to the conception of an MS. These individuals were at a university with about 8,000 students that was highly accredited by the Colombian Ministry of National Education, and which had offered an undergraduate program in Multimedia Engineering since 2008.

The 18 practitioners formed four teams, each with four or five participants. Each practitioner assumed either one or two roles in the team (architects), as shown in Table II. Each team was asked to undertake the following four challenges related to the conception of an MS over a period of four months:

CH1: Identify the stakeholders and the opportunities (based on the interests, motivations, needs, and expectations of the stakeholders) that the MS can offer.

CH2: Conceive the design of an interactive multimedia experience.

CH3: Conceive a responsible design for the MS.

CH4: Carry out a viability analysis for development of the MS.

Each team was given the choice of whether or not to use the MS conception routes for each challenge. Just one team can applied traditional methodologies that were different from the routes on each challenge, and for one time along the four months.

This way of working allowed the greatest possible number of practitioners to work on the routes defined for the conception for the MS, and also took advantage of the extensive experience of both the practitioners and the tutor in other practices and methodologies focused on the UCD and the development of the IS, in order to carry out a comparative analysis.

For the evaluation of each challenge, the case study used a set of surveys composed of open and (mainly) closed questions. Each of the team's practitioners and the tutor answered these four surveys anonymously after the end of each challenge.

The surveys used a five-point Likert scale for questions related to the usefulness of the routes and methodologies or the practices that were used to achieve each of the challenges set for the MS conception. The Likert scale contained the following options: very useful, useful, relatively useful, not very useful, and useless. Meanwhile, for questions related to the team's agility in terms of the learning of the activities and techniques of the route, the five Likert levels were strongly agree, agree, slightly agree, disagree, and strongly disagree.

To enable a comparative analysis between the outcomes obtained for each challenge and the statement in H1 as result of applying the routes, a set of 19 impact factors was defined for all the challenges. These impact factors were to be analysed for each challenge by all the participating teams, including the team that used different methodologies or practices. As sample, the impact factors for CH2 are shown in Table 7, following the code used in the study case, from IF5 to IF11. The agility of the team in terms of the appropriation of the route's activities and techniques was an impact factor evaluated for all the challenges.

Table 7. Impact Factors for the analysis of outcomes vs. hypothesis statement for CH2.

Impact Factor
IF5 Useful for the storytelling collaborative design of the IME.
IF6 Useful to produce alignment between the IME conception, and the interests, needs, expectations and motivations of the stakeholders.
IF7 Useful for the conception of the characters, events, objects, spaces, and times involved in the IME.
IF8 Useful in choosing the most appropriate digital media for the IME.
IF9 Useful in choosing the most appropriate sensory perceptions for the IME.
IF10 Useful in choosing the most appropriate interaction modalities for the IME.
IF11 Agility of the team in terms of applying the Creativity route or other methodologies or practices.

To evaluate the population standard deviation, we carried out separate analyses for the teams that applied the routes for the MS conception and the team using other methodologies and techniques. The tutor's evaluation was included in both measures. Following the recommended guidelines of Sauro [43] for the evaluation of the survey results using a Likert Scale, the equation used to calculate the population standard deviation is given in Equation (1), and was applied for each impact factor:

$$\delta = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2} \quad \textbf{(1)}$$

N is the number of total practitioners applying the route in each challenge plus the tutor, or the team using other methodologies or practices plus the tutor. μ is the arithmetic mean of the results obtained from the questions for each impact factor.

5.1 Limitations of the case study

The limitations of the case study are related to the homogeneity in the professional experience of the practitioners and the tutor, supposing a restriction in the validity of the obtained results using the work routes for conceiving a multimedia system, only to professionals with junior and senior experience as developers of multimedia systems.

This study recognizes different validation experiences on methodological approaches related to the development of multimedia systems, but a limited amount of previous experiences specifically focused on their conception.

6. Results

Following the guidelines of the case study, each team applied three of the four routes for the MS conception or other methodologies or practices for each of the challenges. Fig. 8 shows the results for the population standard deviation for the 19 impact factors making up the four challenges. The variable σ1 (blue line) represents the results for the teams using the four routes for each challenge, while σ2 represents the results for the teams using traditional methodologies and practices to complete the challenges.

The variation in the population standard deviation from the study of the 19 impact factors indicates that the values tend to the mean results from the surveys for the four challenges. Nearly 58% of the results obtained for σ1 were in the range 0.3 to 0.5 while 21% had a value of zero. For σ2, 84% of the values were in the range 0.3 to 0.5.

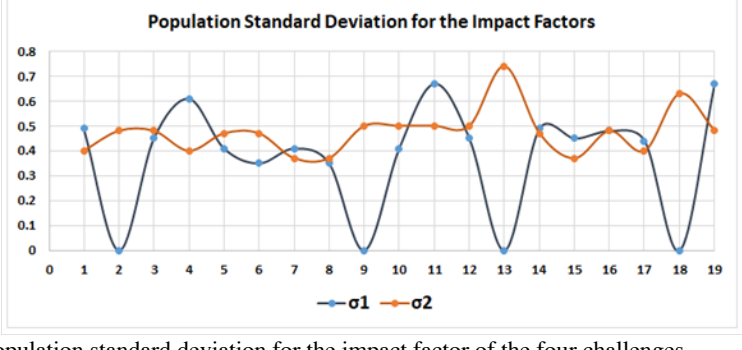

Fig. 8. Population standard deviation for the impact factor of the four challenges.

As an example of the results obtained, the practitioners asked a survey of 18 questions about their experience with the use of the Creativity route to complete the challenge CH2. The results highlighted that more than 86% of the practitioners reported success with the Creativity route in terms of achieving the impact factors IF5 to IF10, although almost 85% of them selected “agree” rather than “strongly agree” for the agility of the team applying the activities and techniques of the Creativity route (IF11).

Fig. 9 (left side) shows the average results for the seven impact factors of CH2 from the survey responses of the practitioners of teams and the tutor. The values of the population standard deviation σ for the impact factors of teams using the Creativity route were zero (IF9), 0.41 (IF5, IF7, IF10), 0.35 (IF6, IF8), and 0.67 for IF11.

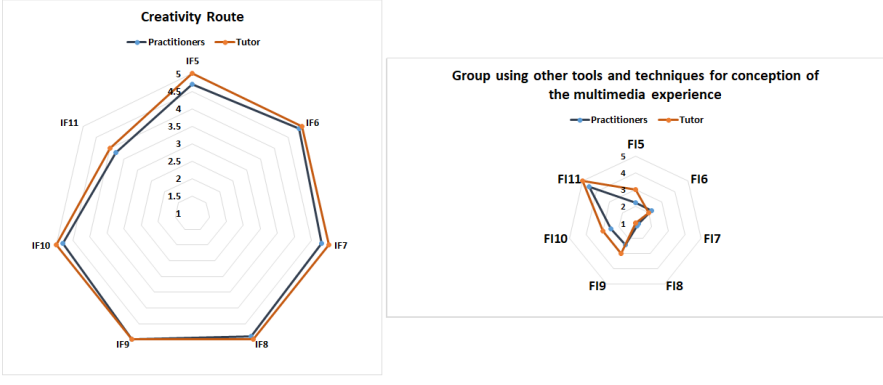

Fig. 9. Average results for the impact factors in challenge CH2 for teams applying the creativity route (left side) and teams applying the traditional UX and UCD practices (right side)

Meanwhile, the right side of the Fig. 9 is showing the results of the impact factors for challenge CH2, when the practitioners applied the agile UX storytelling [33] practices with a UCD methodology as MPIu+a [19]. They reported having difficulties to achieve good results for the impact factors of CH2. Instead, they obtained a greater agility using the storytelling practice and the interactive system development methodology, due to their existing familiarity with these approaches. The values of the population standard deviation σ for the impact factors were 0.37 (IF7, IF8), 0.47 (IF5, IF6), and 0.5 (IF9, IF10, IF11).

This results showed the high value perceived by practitioners when assessing the impact factors, as a result of applying the Creativity route to conceive the interactive multimedia experience, in contrast to other traditional methodologies and practices used as UX storytelling and MPIu+a.

Conclusions and future work

In this study, we propose a new definition and a characterisation of an MS centred on value creation for its stakeholders. The IME, through an envisioning of the theoretical VSD approach for the responsible design, provides the basis for value creation and the motivation for the conception of the MS. The set of work routes provides the basis for a collaborative work for the conception of the MS, through a practical point of view.

The results of surveys carried out as part of a case study demonstrate the contribution of these routes to the process of conceiving an MS, in terms of providing clarity to the team members regarding the work that needs to be done to meet the challenges, using a set of workflows, activities, and techniques. Likewise, the practitioners achieved criteria unification in the collaborative work involved in the conception of the MS.

The values of the population standard deviation for the 19 impact factors of the case study tended to the mean for each of the four challenges. From these results, we

recognise that the practitioners of the different teams had very similar perceptions about the contribution of the routes, activities, and techniques to the fulfilment of the impact factors and the success in each of the challenges.

When the survey results for the tutors are compared to the averages for the practitioners in all the teams, it can be seen that there is a similar and favourable perception of the usefulness of the routes in terms of completing the challenges.

For the Creativity route, the results show a significant contribution in the case study to the conception of the IME, in contrast with the results obtained using traditional methodologies or practices. We observe the main contributions of the route in the collaborative work for the design and integration of the storytelling, the narrative universes, the digital media, sensory perceptions, and interaction modalities, which are more suitable for the value creation in terms of the UX.

The case study showed that the practitioners in the team that used traditional methodologies in challenge CH2 had serious difficulties in aligning the IME with the needs, interests, and expectations of the stakeholders. These difficulties were increased when the team tried to define and align the digital media, sensory perceptions, and interaction modalities that were best suited to improve the UX.

Although the practitioners and the tutor had a high level of knowledge of several methodologies and practices for conceiving storytelling centred on the UX, these traditional methodologies did not offer the level of detail provided by the Creativity route for the conception of an IME and all its specified elements along the route.

However, although the results demonstrated the contribution of the work routes to success in all the challenges of the case study through a collaborative work, both the practitioners and the tutor reported that there was a need to improve the performance of the team in terms to improve the agile learning of the workflow, activities, and techniques of the routes.

Finally, this proposal contributes to enabling a collaborative work environment between the team members to conceive a MS. Still, future work is required to improve an agile approach for the learning and appropriation of the work routes, and future studies to evaluate the impact of the initial competencies of the team members' roles in the collaborative work.

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