Criteria for selecting an Enterprise Modelling Method

Students' Perspectives on ArchiMate and 4EM

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Abstract. *Innovation in enterprises require an understanding of the inherent complexity and dependencies among an enterprise's processes, goals, resources, customers and several other aspects. The choice of a suitable Enterprise Modelling method and language is an essential part of creating this understanding. This paper presents an overview of students' perspectives on the Enterprise Modelling methods and languages 4EM and ArchiMate, and the patterns and criteria for selecting a specific method and modelling language for their assignments. The analysis is based on a post hoc analysis of students' assignments from a course in Enterprise Architecture and Innovation, over a period of four years. The main contributions of this work are a set of selection criteria and recommendations for educators and students in selecting Enterprise Modelling methods and languages.*

Keywords. Enterprise Modelling • Modelling Method • Modelling language • Selection Criteria • Students' Perspectives • 4EM • ArchiMate

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1 Introduction

Enterprises are experiencing enormous and rapid changes in the digital age (Mundra 2018). The needs for understanding organisations, their strategies, processes and how technology could transform and support them to become efficient organisations that could maintain a competitive advantage is greater than ever before. The traditional mindset of in-house developments of IT applications and maintaining a complete overview of all applications and data is changing (Fischer et al. 2007). Organisational cultures are evolving with empowered workers and their needs to understand how their activities contribute to the organisation's strategies. Enterprises are challenged to seek innovative products, services and business models to remain ahead of times and indeed their competitors. Enterprise Modelling and Enterprise Architecture are means of supporting organisations to face the rapid changes they are experiencing today. Enterprise Modelling can help an organisation to understand it's different entities and how these relate to one another and the impacts of changes (Fox and Gruninger 1998). It is the process of creating an integrated enterprise model, where an enterprise model consists of several related perspectives of an enterprise, such as its goals, business processes and the actors involved in the processes (Bubenko et al. 2001; Sandkuhl et al. 2014).

Innovation in enterprises requires an understanding of the inherent complexity and dependencies among an enterprise's processes, goals, resources, customers and several other aspects. The choice of a suitable Enterprise Modelling method is an essential part of achieving this understanding. There is a large number of Enterprise Modelling and Enterprise Architecture methods,

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and comparisons of different methods are reported in the literature, e. g. (Bider 2005; Bock et al. 2014; Kassem et al. 2011). The literature also identifies criteria for selecting modelling methods and languages, e. g. the SEQUAL framework (Krogstie 2012, 2016), and a set of criteria for evaluating reference models, which could also be applied to modelling languages (Frank 2007). The focus on comparing and selecting modelling methods appears to be targeted towards practitioners of modelling in organisations or for experienced modellers. In fact, the literature on teaching modelling methods is limited; a few examples of papers that are focused on teaching conceptual modelling methods are (Sedrakyan and Snoeck 2012; Snoeck et al. 2018); and on teaching Enterprise Modelling includes (Proper et al. 2019). Furthermore, the literature on the selection of Enterprise Modelling methods and comparison of Enterprise Modelling methods appropriate for students and education are limited. This paper aims to contribute to the body of literature on selecting or determining an appropriate Enterprise Modelling method for novices, particularly for teaching purposes.

Today's university students face a rapidly changing world, where new digital and perhaps disruptive technologies are affecting organisations in ways that are not always easy to foresee. This also poses new challenges to teaching relevant subjects to the students (Cameron 2008). Enterprise Modelling and Enterprise Architecture are seen as relevant competencies for today's students in preparing their migration from the university to the rapidly changing world in industry and the public sector. Learning and conducting Enterprise Modelling is also considered as a "complex task based on codified and tacit knowledge that involves mastering theoretical foundations, modelling languages and methods, applying them to practical problems as well as critically thinking and reflecting upon technical terminology and technical language of the targeted application domain" (Strecker 2020). Unlike modelling practitioners, students have limited practical experience and understanding of organisations. Particularly, ICT students have less focus on modelling the business perspectives, which is an essential part of Enterprise Modelling. There is a need to teach students to be able to use modelling languages and approaches other than what they have been exposed to as a part of their traditional Computer Science studies. Hence, the main aim of this paper is to share the students' perspectives from a course on Enterprise Modelling, Architecture and innovation, for the benefit of students and educators.

This paper presents the results from a Masters level university course on Enterprise Architecture and Enterprise Innovation, where students were introduced to two Enterprise Modelling methods, 4EM (Lankhorst and al. 2013; Sandkuhl et al. 2014; The Open Group 2012). One of the aims of the course was to teach students to model enterprises and to prepare students to be able to use any Enterprise Modelling language, or more precisely, be able to use also other languages than the ones they have used during their studies, i. e. prepare the students as future problem solvers. Hence, one reason for choosing these two specific modelling approaches is because they offer quite different modelling languages and structures for describing the same concepts in an enterprise. At the same time, these two modelling languages also share a considerable overlap of modelling concepts. Furthermore, both the languages support modelling of the business and IT perspectives and relationships among them, which are essential for modelling Enterprise Architecture. Exposure to different approaches and modelling languages to model the same enterprise situations can contribute to reinforcing their learning and easy transfer of learning (Ong and Jabbari 2019). These students are in their final years of study and hence, the course is designed to support them transition to their working life and apply what they have learned at university in real enterprise situations.

The experiences from the course and the assignments from the students have been analysed post hoc to identify the criteria that affected the students' choices of the modelling method and language. The main contributions of this paper are a set of selection criteria and recommendations to help students and teachers select modelling methods and languages, for educational purposes. Furthermore, while we were able to obtain literature that compared ArchiMate to other methods e. g. (Bock et al. 2014), the literature on 4EM, apart from the contributions by the creators of the method, is limited, e. g. (Kinderen and Kaczmarek-Heß 2020). Hence, one of the motivations for this work is also to share our experiences with using 4EM as a modelling method for students.

The rest of this paper is organised as follows: sect.2 provides an overview of work related to modelling methods, teaching and learning Enterprise Modelling methods and selecting an Enterprise Modelling language; sect.3 describes the research method; sect.4 describes the Enterprise Architecture and Enterprise Innovation course design and the pedagogical approach; sect.5 describes the students' perspectives and their feedback on 4EM and ArchiMate; sect.6 proposes a set of selection criteria for the modelling methods based on the students' perspectives; sect.7 discusses the results and provide recommendations to students and teachers on the selection of modelling methods and sect.8 summarises the paper and presents directions for future work.

2 Related Work

There are several definitions of an Enterprise Model that bring forth multiple interpretations of enterprises and models; e. g. an enterprise model is considered as a computational representation of the structure, activities, processes, information, resources, people, behaviour, goals and constraints of a business, government, or other enterprise (Fox and Gruninger 1998). Another interpretation considers an enterprise model as consisting of several sub-models (Vernadat 1996), which can be considered as the different perspectives of an enterprise, such as goals, processes and actors (Sandkuhl et al. 2014). Some definitions emphasise models as abstractions and conceptualisations of a domain (Lankhorst and al. 2009) and, as conceptual models of software systems integrated with models of their surrounding action systems, such as business process models, as well as inter-organisational aspects (Frank 2013). A model is also defined as an abstraction externalised in a professional language. A model is assumed to be simpler than, resemble and have the same structure and way of functioning as the phenomena it represents (Krogstie 2012). A phenomenon is something as it appears in the mind of a person. The world is perceived by persons to consist of phenomena and a phenomenon can be perceived to exist independently of the perceiving person (often denoted as the 'real' world) or be perceived to be purely mental. According to Krogstie (2016), a conceptual model is traditionally defined as a description of the phenomena in a domain at some level of abstraction, which is expressed in a semi-formal or formal visual (diagrammatical) language. Thus, an Enterprise Model can be considered as a conceptual model that represents phenomena on an enterprise level.

Most definitions of Enterprise Models identify the need to model the different aspects of enterprises such as goals and business processes. An Enterprise Model also takes into account the relevant real-world properties and could represent the current state of a real-world enterprise situation and/or a future state of an enterprise (Sandkuhl et al. 2014). One view of a model could thus be considered as a conceptualisation of the real world as it is perceived. Enterprise Modelling is also aimed at supporting the "conjoint analysis of business and IT to foster their integration", specifically to address the concerns of the different stakeholder groups (Frank and Bock 2020). Given the broad span of the ideas and scope encompassed in the myriad of definitions of Enterprise Models, it can be beneficial to narrow the scope of a model for the task at hand, such as teaching novices to create Enterprise Models of real or realistic enterprise situations.

For the purposes of teaching Enterprise Modelling to masters students, modelling can be considered as conceptualising and describing 'a set of abstract or concrete phenomena in a structured and, eventually, in a formal way', (Sandkuhl et al. 2014, p. 25), and the outcome of the modelling process can be documented using a modelling language, which may be textual or visual. A method describes the 'approach to Enterprise Modelling by formulating a set of underlying principles as well as detailed and systematic work procedures' (Sandkuhl et al. 2014, p. 26). Thus, Enterprise Modelling can be described as the process of creating an integrated Enterprise Model, where an enterprise model consists of several related perspectives of an enterprise, such as its goals, business processes and the actors involved in the processes (Bubenko et al. 2001). Enterprise modelling is used in describing Enterprise Architectures, which focus on aligning and bridging the business and Information Technology in enterprises (Lankhorst 2004).

The following sub-sections provide brief overviews of the literature related to Enterprise Modelling methods and languages, teaching and learning conceptual and Enterprise Modelling and on comparing and selecting Enterprise Modelling methods and languages.

2.1 Enterprise Modelling methods and languages

Several Enterprise Modelling and Enterprise Architecture methods are available in the research and education domains (Krogstie 2016). More recently, as Enterprise Modelling and Enterprise Architecture have become widely accepted in private and public organisations, Open Source and commercial tools have become available to support some of these methods. Some of the earlier overviews of Enterprise Modelling methods are available from (Fox and Gruninger 1998) and (Vernadat 1996), which provide a good overview of some of the earlier methods, such as ARIS, GRAI-GIM and the IDEFx languages. The concept of Active Knowledge Models (AKM) is described and explained through several examples in (Lillehagen and Krogstie 2008). AKM focusses on the externalisation of knowledge and provides a generic meta-model and modelling and support capabilities for collaborative modelling. A number of different types of modelling methods are available for varied purposes. Several methods focus on business process modelling; e. g. Business Process Modelling Notation (BPMN) and some Enterprise Modelling methods have business processes in focus, e. g. DEMO (Design and Engineering Methodology for Organizations) (Dietz 2001), and MEMO (Multi-Perspective Enterprise Modeling). MEMO brings together the perspectives of IT and business, and provides an extensible set of Domains Specific Modelling Languages (DSML) to support the different professionals' and stakeholders' perspectives (Frank and Bock 2020).

Some of the inspirations for creating new Enterprise Modelling languages are to understand organisations, identify their needs for innovation and change, their processes and support them in aligning their IT and business strategies. 4EM (for Enterprise Modelling) is a language designed in response to these inspirations and provides a means of modelling several aspects or perspectives of an enterprise, such as goals, business processes, organisational and technological components, business rules and concepts, and relationships among them (Sandkuhl et al. 2014). The 4EM language is a modular language, where each perspective of the enterprise could be modelled as a module or sub-model. The 4EM modelling language includes the following enterprise perspectives: goals, business processes, actors and resources (organisational view), business rules, technical components and requirements and concepts (which can be used to model concepts that are not supported by 4EM such as the product or service views). The language includes a set of object types and relationship types both within each perspective as well as across the different perspectives. The 4EM method and language are based on extensive experience with Enterprise Modelling in industry and promotes a participatory Enterprise Modelling approach, where the modelling experts and domain experts interact in several modelling sessions (Persson and Stirna 2010). The separation of concerns that is a part of the design of the 4EM modelling method has been suggested to decrease the cognitive load on modellers (Bjeković et al. 2013).

One of the most popular Enterprise and Enterprise Architecture Modelling languages that is used today is ArchiMate (Lankhorst and al. 2013; The Open Group 2012), which supports modelling in a way compliant with The Open Group's Architecture Framework (TOGAF) (Josey 2018). The inspirations for ArchiMate were to capture the Enterprise Architecture and the change or migration process of the architecture. The ArchiMate Enterprise Architecture language was originally developed to support the TOGAF method, to provide a uniform representation for diagrams that describe Enterprise Architectures. It is a layer-based method, and the initial version of ArchiMate language (ArchiMate 2.0) defined 3 layers of an Enterprise Architecture: (i) Business layer, which offers products and services to external customers; (ii) Application layer. which supports the business layer with application services; and (iii) Technology layer, which offers infrastructure services needed to run applications. The language has since then evolved to support a fourth layer: (iv) Motivation and additional capabilities to support the project management and migration of the Enterprise Architecture. ArchiMate has been compared to other modelling languages in the literature; e. g. with BPMN in (Penicina 2013) and with DEMO and MEMO in (Bock et al. 2014). While BPMN provides a holistic view of a complete business processes from the start to the end, it lacks the structural aspects of a business process such as actors, data objects and IT components, which are essential components in understanding the complete process and what it requires. In Bock et al. (2014), the authors proposed a framework for analysing and comparing modelling languages, which identified three criteria: way of thinking, way of modelling and way of working. Archimate differs from DEMO and MEMO in their way of thinking as Archimate was an initiative from the industry, while DEMO and MEMO started as academic research. In the way of modelling, Archimate and MEMO both provide meta-models. However, MEMO provides meta-models and DSML for the different modelling perspectives while Archimate does not provide specific DSML. The way of working in the case of Archimate is focused on managing the Enterprise Architecture process, while MEMO focusses on creating, maintaining and extending comprehensible Enterprise Models with multiple perspectives, for different purposes.

The two modelling methods and subsequent modelling languages, ArchiMate and 4EM, present Enterprise modelling in very different ways. 4EM takes an enterprise perspective approach, distinguishing the different perspectives, such as business processes, organisations and goals. Students are often exposed to these perspectives in separate courses, e. g. courses on process modelling or requirements modelling. However, 4EM provides the different perspectives within a single modelling language, with modelling constructs to relate them. The sub-models in 4EM provides the language constructs to focus on each perspective of an enterprise separately, e. g. the goals or the processes. At the same time, it also supports the language constructs to build a holistic model of an enterprise by providing relationships among the different perspectives. 4EM does not focus on any specific Enterprise Architecture approach or methodology or promote a particular change process within an enterprise. It provides the language constructs to capture and describe enterprise situations to make sense of situations, which could be relevant to identify problems or indeed to improve or change the current situation. The focus of 4EM is on the enterprise business processes and the goals. The language constructs to model the technological components of an enterprise are limited. ArchiMate, on the other hand, was designed to bridge the business strategy to the IT strategy and therefore considers the enterprise in terms of layers or as a sequence of processes depicted through the TOGAF ADM (Architecture Development Method) process. Thus, the approach focusses on the modelling concepts that are relevant for each of these layers (motivation, business, information and data and technology) rather than the specific perspectives as in 4EM. The enterprise perspectives are thus mixed in the layers, e. g. the motivation layer includes goals, the drivers and performance assessments indicators; the business layer includes the business processes, actors and resources as well as business data elements related to the business layer. Thus, the business layer includes many of the enterprise perspectives that are included in 4EM. In contrast to 4EM, the application, data and technology layers provide a rich set of language constructs to model the technological components and the technology infrastructure of the enterprise. While this is a strength for modelling Enterprise Architecture, the mix of several enterprise perspectives in the business layer can be challenging for students to be able to focus on the different perspectives of an enterprise. ArchiMate also splits the modelling concepts into passive structures (Open Database Alliance) behaviour (processes) and active structure (actors and roles).

2.1.1 4EM and ArchiMate Modelling Languages

The modelling needs for the students come from the learning goals and outcomes identified for the course, which include theoretical insights into business and enterprise modelling, service innovation and the methods for analysing organisational situations and modelling them as well as developing the practical skills to create business and enterprise models that enhance the understanding of the design of IT (TDT4252 - Enterprise Architecture for Enterprise Innovation 2022). As such, relevant modelling concepts include business and IT related ones, e. g. business drivers and goals, business processes and actors and IT and technical components such as data elements, software and hardware applications. Both 4EM and ArchiMate modelling languages include the language elements that support the learning goals and there is an overlap of enterprise perspectives. However, the motivations for the design of ArchiMate and 4EM are very different and this can be seen in the modelling languages. Nevertheless, both the languages provide sufficient modelling constructs to meet the needs of Enterprise Modelling students and for the needs of most enterprise situations. A comparison of the modelling perspectives in the two languages are summarised in tab. 1, where the left hand side of the tab.shows the sub-models or enterprise perspectives in 4EM and the right hand side of the tab.shows how the different enterprise perspectives are included in the different layers of the ArchiMate modelling language.

To further illustrate the differences between 4EM and Archimate modelling, we have included an example model created by using each of the modelling languages. The models describe an enterprise that delivers coffee and coffee machines to other companies. The motivation for the enterprise model was to improve the value to their customers through improving their delivery process. The purpose of the enterprise model was to obtain an overview of the delivery process. The models show how one of the goals of the enterprise, ‘to reduce delivery costs by 15 %’, could be achieved. Both the models show additional, related goals, the delivery process or parts of it and the customer.

The model created using ArchiMate is shown in Fig. 1, where a detailed goal model is shown. The Goal of interest is connected to the Business Process ‘deliver goods to non-ordering customers’ (through another related goal). The Business Process is supported by the Application Component ‘EVATIC Mobile’, which is supported by Application Functions (e. g. ‘Register delivered goods’) and the Device ‘Mobile’. The ‘customer’ is modelled as a Business Actor. The enterprise perspectives included in this model are Goals (Motivation Layer), Business Processes, Business Actors and Application Component (Business Layer) and Device (Technology Layer).

The model created using 4EM is shown in Fig. 2, which also includes the Goal, Business processes and Organisational perspectives of an enterprise. The Goal ‘deliver goods to non-ordering customers’ is related to a Sub-process ‘receive driving list CustomCoffee’. The 4EM language is designed to simplify modelling components into their subcomponents, e. g. Processes and Sub-processes;

Table 1: Components of 4EM and ArchiMate methods

4EM enterprise perspectives	ArchiMate layers & corresponding enterprise perspectives
Goals	Motivation layer, includes Goals and Requirements
Business Processes	Business layer, includes Business Processes
Actors and Resources	Business layer, includes Actors, Roles and Organisational Units
Concepts	Not explicitly defined. Business objects, in Business layer, could be considered similar
Business rules	Motivational layer, includes Principles and constraints
Technical Components and Requirements	Application and Technology layers, includes Component, Service, Interface

hence this is evident in the model illustrated in Fig. 2. Unlike the ArchiMate model in Fig. 1, the 4EM includes additional details from the Organisational perspective, where several roles and an Organisational Unit is identified. A single Technical Component, ‘Resource 1 EVATIC System’ is included in the 4EM model, whereas the ArchiMate model includes components of the EVATIC system.

2.2 Teaching Conceptual and Enterprise Modelling

Learning conceptual modelling encompasses understanding the theoretical foundations, modelling languages and methods and applying them to real world problems (Rosenthal and Strecker 2019). This also requires the ability to critically reflect upon an application domain and assess the suitability of a modelling language and method for the domain and the situation at hand. A literature review on learning conceptual modelling conducted by Rosenthal and Strecker (2019) identified learning support tools, in particular, modelling tool support, and feedback as emerging research themes. That study also noted the limitations of literature that addressed learning paradigms related to conceptual modelling.

An analysis of educational material as a step towards a systematic educational framework for Enterprise Modelling was conducted by (Bogdanova and Snoeck 2017). They proposed an adaptation of the Bloom’s Taxonomy (Anderson and Krathwohl 2001) for domain modelling and identified four knowledge levels and levels of scaffolding. Their study noted that the higher cognitive processes identified in the Bloom’s Taxonomy, such as evaluate and create, which are some of the important processes to create models, were insufficiently addressed in the educational material. The revised Bloom’s Taxonomy based framework proposed by Bogdanova and Snoeck (2017) has been used to teach domain modelling of Smart Cities (Bork 2019).

The cognitive process of learning conceptual modelling and the modelling difficulties experienced by novice modellers were reported in (Rosenthal and Strecker 2019). Although their study was not focused on the modelling tool, the authors report that some of the participants of their study made remarks and had criticisms of the modelling tool. Some of the difficulties experienced by novice modellers include identification of as well as the distinction between entity and relationship types and determining the cardinality of relationships. One of the challenges in learning to create enterprise models is the dual complexity of understanding and conceptualising the problem domain and representing it as a model (Proper et al. 2019).

The Open Models Laboratory (OMiLAB), focused on the education and research in the domain of conceptual modelling, provides advice for teachers of conceptual modelling on structuring the teaching and assessment activities (Miron and Douligeris 2017). They also provide an overview of available tools for creating models. However, they do not provide explicit advice on the choice of a modelling tool.

2.3 Comparing and Selecting Enterprise Modelling Methods

The choice of an appropriate Enterprise Modelling method has been identified in the literature as an important part of understanding the inherent

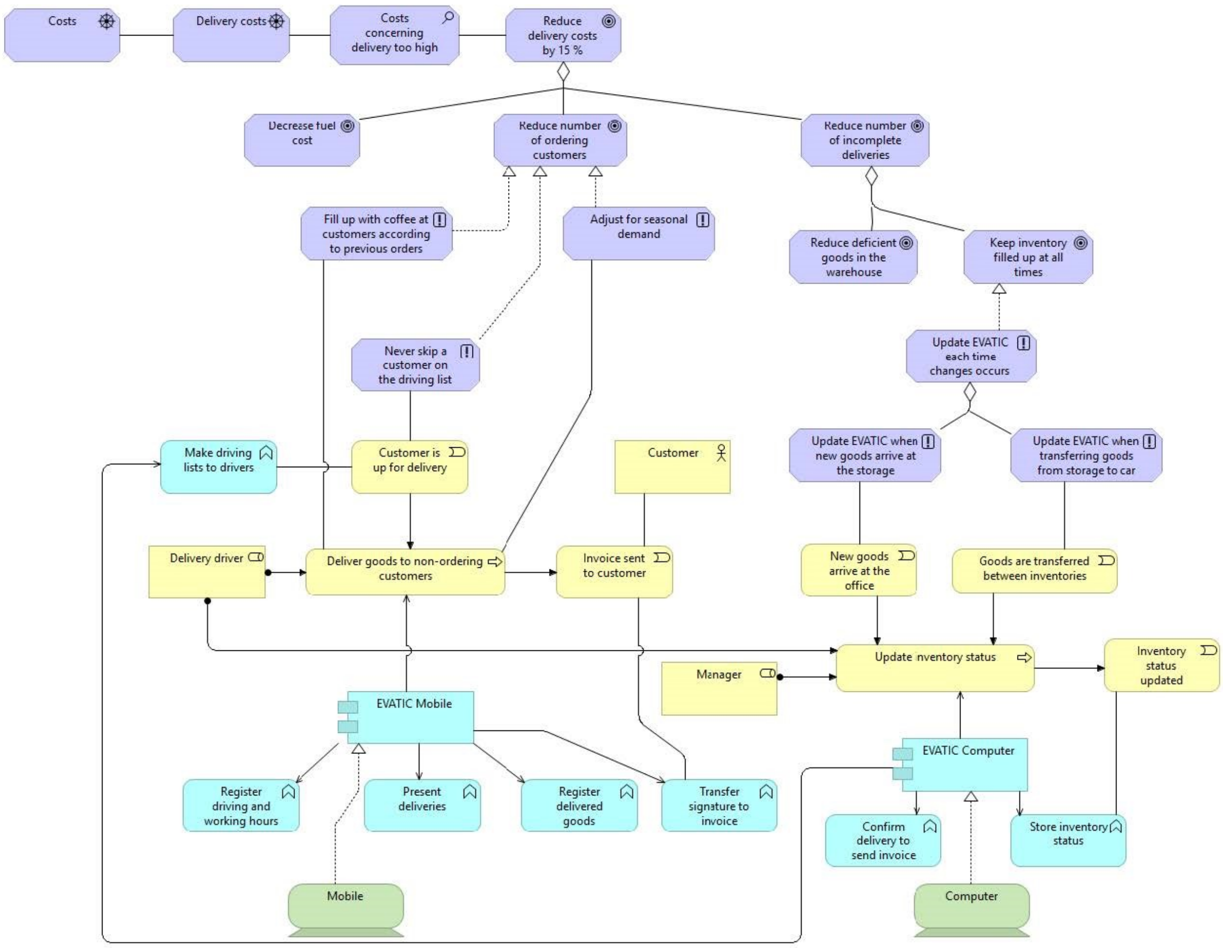

Figure 1: Example of an enterprise model created using ArchiMate

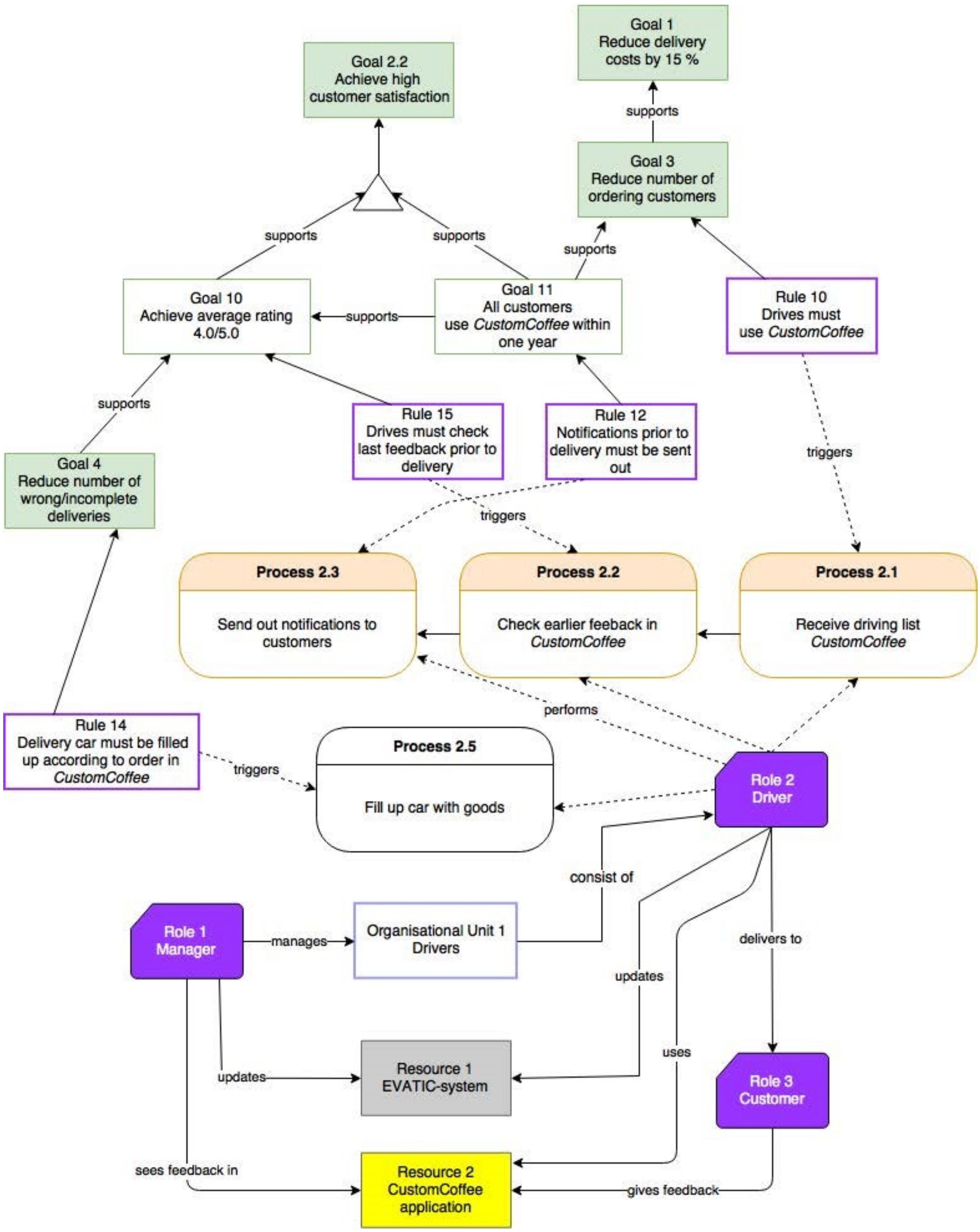

Figure 2: Example of an enterprise model created using 4EM

complexity in organisations (Bock et al. 2014). An analysis framework for the selection of Enterprise Modelling approaches was proposed and the framework was illustrated by comparing three methods including ArchiMate (Bock et al. 2014). The three criteria identified in this framework for analysing methods were (i) the way of thinking and the motivation for the design of the method; (ii) the way of modelling such as the modelling concepts and the mechanisms for defining them; and (iii) the way of working and applying the method. While these three criteria are important for creating models, organisations often need to manage the system development processes. Thus, two additional criteria have been proposed: the way of managing the system development such as human resources and the way of supporting the system development process such as through automated tools (Land et al. 2009).

The purpose of modelling has been proposed as an important selection criterion for a modelling language by several authors, e. g. (Kassem et al. 2011; Proper et al. 2019). For example, a model could be for descriptive and learning purposes, to support decision making or to enact processes. The purpose of the model could be considered as fulfilling the intended use of the model and meeting some of the expected qualities of the model. Proper et al. (2019) emphasised the importance of understanding the domain that is to be modelled and the suitability of the language to the domain, such that the model can fulfil its intended purpose.

Addition selection criteria proposed by Kassem et al. (2011) are the ease of communication between stakeholders, the characteristic of the modelling environment and characteristic of the modeling technique itself. Another important aspect that was identified in the elaboration of the purpose of the model was if the concepts in the model were ‘active’ or ‘passive’ (Aguilar-Savén 2004; Bider 2005). This is perhaps important to consider as the ArchiMate method considers passive and active objects. Aguilar-Savén (2004) proposed a framework to classify Business Process Modelling (BPM) methodologies according to their purposes based on their ‘active’ or ‘passive’ behaviour and provided an overview of several existing methods and where they could be positioned on the framework.

To ensure the ‘right’ choice of a modelling tool, in particular for BPM methods, the following three sets of factors have been proposed: (i) properties of modelling objects, i. e. business processes, (ii) characteristics of the modelling environment, (iii) intended use of the model (Bider 2005). The characteristics of the modelling environment and the purpose of the model or the intended use of the model appears to be of relevance for more than one author. Another set of criteria for the selection of BPM methods are the ease of use, ease to understand, scale, flexibility, formality and time (Aksu et al. 2010).

The choice of a modelling language is affected by several factors such as the cognition or understanding of the modeller, the notation used in the language, the phase of the modelling and the quality of the language (Ong and Jabbari 2019). The notation used in the language does seem an important factor also based on the studies conducted to identify modelling difficulties experienced by both experienced and novice modellers (Rosenthal and Strecker 2019; Rosenthal et al. 2020). A framework for evaluating the quality of modelling languages and models, SEQUAL, proposes several qualities which are also relevant in selecting a modelling method (Krogstie 2012). Language quality relates to the appropriateness of the language (to the domain to be modelled, knowledge of the model developers and interpreters, tool handling, and organisational setting to create good models, according to e. g. physical, syntactic, semantic, pragmatic and deontic criteria to ensure that the model meets the purpose it was designed for (Krogstie 2012). The SEQUAL framework also contains a generic modelling method, but not specialised for Enterprise Modeling. A proposed list of desirable characteristics for a language for conceptual modeling are expressibility, clarity, simplicity, orthogonality, semantic stability, semantic relevance, validation mechanisms, abstraction mechanisms, and formal foundation (Halpin and Morgan 2008).

Enterprise Architecture methodologies, most of which also encompass Enterprise Modelling, have also been compared. Some of the criteria for comparison or for consideration when an enterprise selects an Enterprise Architecture methodology include the availability of information about the methodology, business focus, the completeness of the language and time to value (Sessions 2007).

Several authors provide frameworks to compare modelling methods and languages and characteristics for modelling languages. However, we did not come across any studies that share their experiences and knowledge about Enterprise Modelling languages, particularly based on students' feedback.

3 Method

The choice of a research method has been inspired by the teacher's motivation to achieve student satisfaction and enhance students' engagement in their learning activities. The Action Research methodology has been considered as an appropriate overall approach (Gibbs et al. 2017), where a cycle of planning, action and reflection is considered, to improve the course contents and learning activities every year. Actions Research provides a means of systematically inquiring and analysing qualitative data that can stimulate self-reflection, critiquing and improving the practice of teachers and educators (McCutcheon and Jung 1990). In our work, the aim of the teachers was to improve the curriculum and teaching approach and practice every year, by reflecting upon the previous years' courses and making improvements for the next year. Hence, the teachers engaged in prolonged Action Research, enhancing their knowledge about the students and adjusting the teaching practice and learning resources based on the students' feedback every year. While Action Research has been the overarching approach for improving the course, more specific methods for data collection and analyses have been used for specific activities, such as the results reported in this paper.

Each year, the class identified three students that acted as a reference group to represent the students and to provide feedback to the teacher. In addition to that, an online discussion forum was created on the Learning Management System so that students could pose questions and provide feedback to the teacher. Furthermore, at the end of the course, a final questionnaire was provided to obtain feedback from the students, which were used to improve the course over the years. The teachers' experiences, the feedback from the reference group and the students provided the basis for reflection. The teachers engaged in a process where data, such as those reported in this article, contribute to the teachers' inquiry about the teaching practice and the students' perspectives (Waters-Adams 2006). Adjustments to the course are made every year to ensure that the students' needs are met. For example, feedback and example models from students are used to illustrate challenges related to modelling, and learning activities are refined or new activities are designed based on students' feedback.

The main data for the research presented in this paper are from the questionnaires at the beginning of the course to understand the study background and previous modelling experiences of the students, the questionnaires at the end of the course and the models and reports that were submitted by the students as a part of their course work. The responses to the questionnaires consisted of answers to both multiple-choice questions and open-ended answers. The multiple-choice responses are analysed using descriptive statistical methods. The analysis of the open ended questions and the contents from the reports are inspired by the Qualitative Content Analysis (QCA) method (Moretti et al. 2011), where the focus was on providing a simple overview of the data. The steps in the analysis included identification of the main themes or categories, structuring them as pros and cons about each modelling language and clustering them. The clusters formed the basis for identifying the relevant criteria in selecting an Enterprise Modelling language. Since the data was gathered over several years, the analysis was conducted in stages. Thus, the list of themes identified after each year were used as the starting point for the next year and the list of themes has evolved as data from subsequent years have been analysed.

The research presented in this paper is a post-hoc analysis of the questionnaires over three years and students' reports over four years. A post-hoc analysis of the data collected over several years serves also as an additional reflection tool for the teacher (Sharif et al. 2005), and facilitates sharing experiences based on the wealth of information gathered over the years (Curran-Everett and Milgrom 2013). Some of the problems associated with post-doc analyses have been addressed in the literature such as hypothesising after the results are known and a potential lack of transparency (Hollenbeck and Wright 2016) .

4 Enterprise Modelling and Enterprise Innovation

The analysis presented in this paper is based on the assignments submitted by students in the Masters level course, Enterprise Architecture and Enterprise Innovation, at the Computer Science Department, at the Norwegian University of Science and Technology in Trondheim, Norway. The main learning outcomes for the students were to establish theoretical insights into Enterprise Modelling and the methods for analysing organisational situations and modelling them and to establish practical skills in creating good Enterprise Models. The curriculum covers Enterprise Modelling and Architecture, Innovation, Service Design and Business Modelling methods. The motivation for the use of complementary methods is to increase students' understanding of the bigger context of organisations and how Enterprise Modelling complements and is complemented by more than one type of modelling activities; e. g. (Caetano et al. 2017).

4.1 Pedagogical Approach

The overall pedagogical approach adopted in the course brings together ideas from several learning approaches; see Fig. 3. A socio-constructivist approach (Vygotsky 1978), encourages the learners to construct their own understanding of the world based on their own understanding of a situation, and to play an active role in the process of constructing meaning and knowledge. As such, the students were required to bring their own examples to discuss and model, such that they had an affinity and understanding of the enterprise situation that they would analyse and model. Furthermore, this promoted students' ownership of learning and their active engagement in the learning process. The possibility for students to make choices such as selecting their cases to model and the choice of an enterprise modelling language also contributes to improving their self-determination (Chan et al. 2014). Another advantage of students providing their own cases created an opportunity to expose students to a variety of enterprise situations, rather than a single example provided by the teacher.

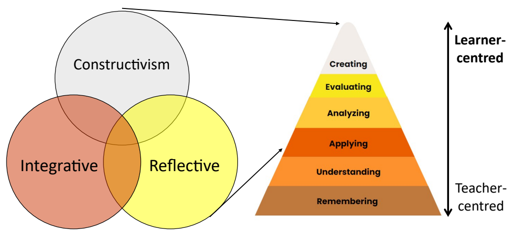

Figure 3: Pedagogical approach

An integrative approach to learning, (Woodside 2018), was adopted by encouraging learners to bring their practical or real world experiences into the course and to analyse them by using the Enterprise Modelling, Service Design and Business Modelling methods taught in the course. As the students were in their final years of study, the integrative approach was intended to prepare students to apply their learnings into practical situations, as watching the teacher create models is not enough (Frantzeskaki et al. 2008). A reflective approach, (Brockbank and McGill 2006), encouraged students to reflect and discuss the design choices in their models as well as present their ideas and work to their peers. Students were provided regular feedback (Snoeck 2017) and encouraged to reflect upon their models and how well they met the purpose of the model to create the intended value for the enterprise.

As shown in Fig. 3, the course was designed to address the higher levels of the Bloom's Taxonomy, (Anderson and Krathwohl 2001), where the students were required to apply, analyse and evaluate their understanding of the theory taught in the course. By identifying problems from the real world and abstracting them as enterprise models, they exercised their creativity.

The pedagogical approach was learner-centred where students' contributions and engagement were incorporated as learning activities, and the students had to apply their knowledge to model their selected cases. However, introduction to basic theories and modelling languages were provided as traditional lectures. Emphasis was given to the process of learning. The weekly tutorials were designed as interactive sessions where students could interact with each other, the teacher and the teaching assistants and discuss their cases and challenges and support one another. The tutorials were also an arena where students received regular feedback from their peers and the teacher.

One of the challenges of students providing their own cases for their assignment is to ensure a uniform evaluation of the reports. Thus, learning targets and expectations of the models and the reports were provided as an evaluation rubric. Given the emphasis for the students to understand real life enterprise situations and to apply their knowledge from the course, less emphasis was given to the more theoretical aspects of enterprise modelling such as the completeness of the model.

4.2 Course Design

The students were required to identify a relevant organisational situation that they could analyse by applying theory and methods from Enterprise Modelling and by creating an Enterprise Model using both 4EM and ArchiMate. Literature shows that a user's ability to grasp modelling concepts is dependent on their exposure to multiple modelling techniques and that, in reality, several modelling techniques may be used during the different phases of modelling (Ong and Jabbari 2019). Furthermore, reflecting upon the choice of a modelling language based on the needs of the case to be modelled has been identified as one of the challenges in learning Enterprise Modelling (Proper et al. 2019) and complies with the pedagogical approach described earlier. Hence, both 4EM and ArchiMate were used in the course.

The minimum requirement for the Enterprise Model was to include three or more perspectives of an enterprise, e. g. processes, goals and organisational aspects. The motivations for getting the students to create models of the same enterprise using both 4EM and ArchiMate were to expose them to using multiple methods and tools, to help them appreciate the strengths and weaknesses of both methods and the suitability of the modelling languages for the different types of organisational situations. An overview of the process followed during the course is shown in Fig. 4.

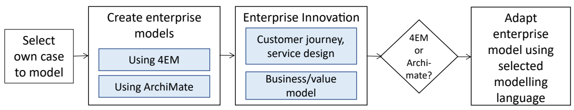

Figure 4: Overview of the process during the course

To develop students' understanding of agility in enterprises and to enhance their appreciation of the value of Enterprise Models and architecture in supporting innovation in enterprises, the students were then required to apply Service Design methods to innovate one or more services, with focus on the customer or the end user. This is also to align with the current trends emerging as a consequence of digital transformations and the shift from a product-centred to a service-centred approach (Gils and Proper 2018). Most Enterprise Modelling languages stem from an Information Systems perspective and focus on the enterprise, where the users or the customers and their perspectives are often reduced to technical requirements of a system (Becker et al. 2010). To draw the students' attention to the customer's experience of a new and innovative service, they were asked to create customer journeys and service blueprints. As part of the enterprise innovation, the students were also required to develop a sustainable business or value model for the new service, drawing their attention to not only the economic sustainability of the organisation, but also the broader perspectives of environmental and societal sustainability (Joyce and Paquin 2016).

Following the innovation task, they were required to adapt or enhance their Enterprise Models, using either 4EM or ArchiMate, thus encouraging them to think of a longer term perspective of Enterprise Modelling in the enterprise (Sandkuhl et al. 2018). This process is illustrated in Fig. 5. The students were asked to make an informed and intentional choice of the Enterprise Modelling language (4EM or ArchiMate) and to justify their choice.

Once the models were completed in either 4EM or ArchiMate, the students were required to evaluate if their models meet their intended purposes. The SEQUAL framework and other criteria for the evaluation of models, e. g. from (Sandkuhl et al. 2014) were presented to the students. The students were not instructed to use any of the evaluation related material in choosing a modelling language (4EM or ArchiMate) for their final models and therefore it is not possible to say if the evaluation methods may have influenced the students' choices. In addition to the Enterprise Models, the students were required to submit a report describing their models, the purpose of their model and the model design rationale and the innovation. Furthermore, they were asked to explain why they chose 4EM or ArchiMate for the enhancements of the model, to support the innovation and the new service(s).

The course is offered during one semester, every year, and lasts from mid-August to early December. The assignment is introduced during the 3rd week of the course and the deadline for delivering the final models and the reports were in mid-November. The students were expected to work regularly on the assignment throughout the semester. Challenges identified by the students were addressed during the weekly lectures, tutorials and in the class discussion forum available on the learning management system. Intermediate checkpoints were used to check progress and ensure that the students received timely and relevant feedback.

5 Students' Perspectives

The results described in this paper are based primarily on the students' Enterprise Models and the analysis of the contents of their reports, from the courses given between 2016 – 2019. The questionnaire data are from three years. The main sources of data are:

- Students' reports from 2016-2019, as a part of their assignments. The total number of reports that have been analysed are 139.
- Students' models from 2016-2019, in both 4EM and ArchiMate.
- Pre-intervention (background) online questionnaires from 2017-2019, to establish the baseline knowledge of the students on modelling methods.
- Post-intervention (final) online questionnaires from 2016-2018, to obtain information about their experience and feedback for improvements in future courses.

The response to the questionnaires was voluntary and hence the numbers of students that responded to the final questionnaires each year were less than those that completed the course, i. e. the no. of students that submitted reports and models. A greater number of students responded to the background questionnaires each year as students were allowed to attend the first few weeks of classes before they decide which courses they will pursue and be examined.

The data from the different sources have been analysed using both QCA and quantitative methods, e. g. descriptive statistical methods for the questionnaire data, which are presented as bar graphs in the following sub-sections. The students' reports have been studied to understand their reasons for choosing one language over the other. Some of the qualitative analyses relevant to

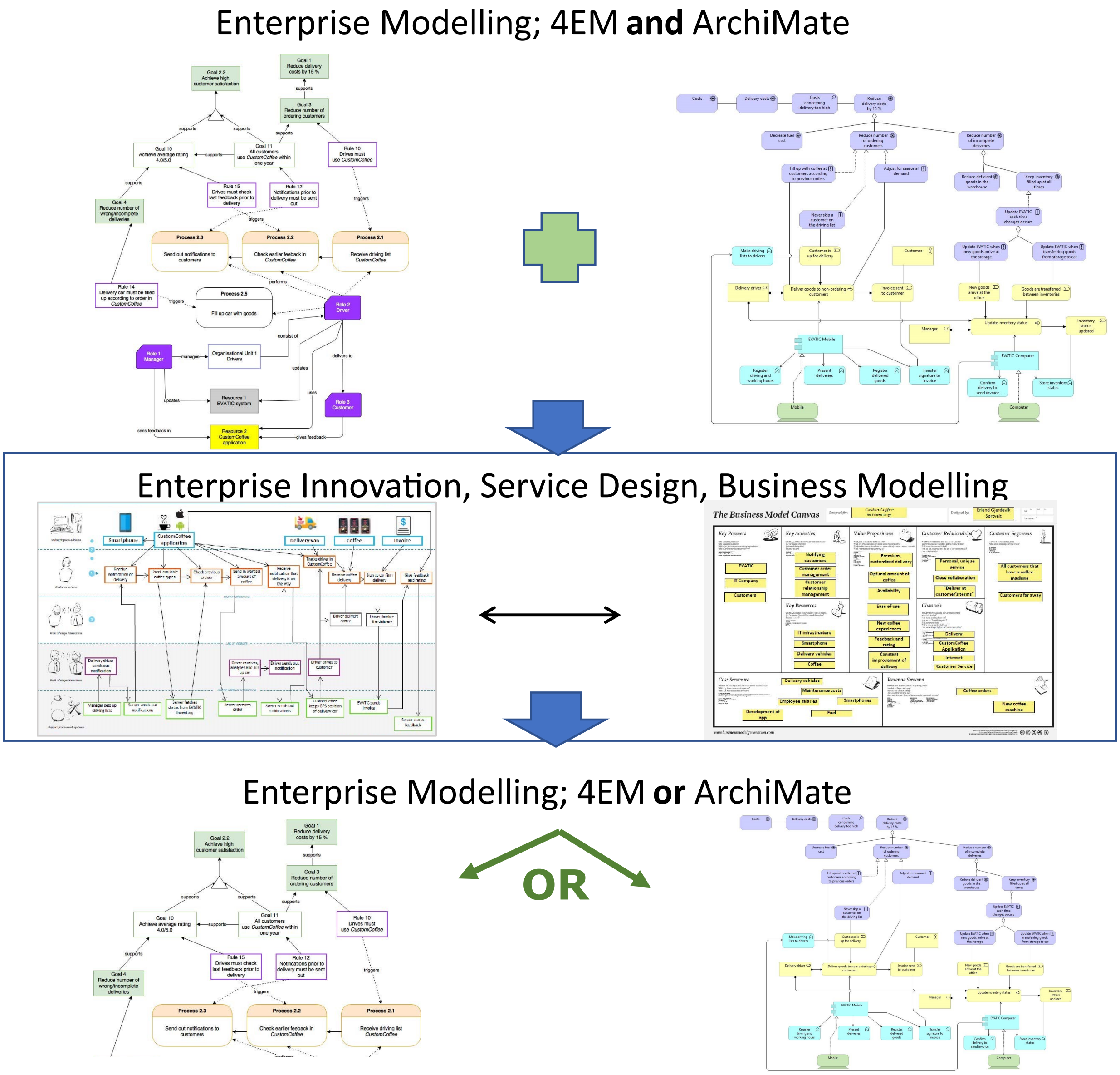

Figure 5: Enterprise Modelling and Innovation process for the student assignments

understanding the students' perspectives in choosing a modelling method are presented as the pros and cons of both the modelling methods.

5.1 Prior knowledge about 4EM and ArchiMate

At the beginning of the course each year, the students were asked to complete a background questionnaire about their study background and familiarity with different modelling languages. This was designed to improve the teacher's understanding of the needs of the students. Since 2017, students have been asked explicitly about their familiarity with 4EM and ArchiMate modelling methods. The number of responses received were 38, 28 and 21 in 2017, 2018 and 2019 respectively. A high percentage of students were familiar with modelling methods such as Entity Relationship (ER) modelling and BPMN. However, very few had used 4EM or ArchiMate and only a few had knowledge about them through reading. Both these methods were new to most of the students. An overview of the numbers (in percentages) is shown in Fig. 6. While most of the students reported over the three years that they did not know about the modelling languages, it can be seen that a small percentage of students from 2019 have read about them and had prior theoretical knowledge about both the languages. Note that since the background questionnaire in 2016 did not ask explicitly about 4EM and ArchiMate, the responses for 2016 are not included in the graph.

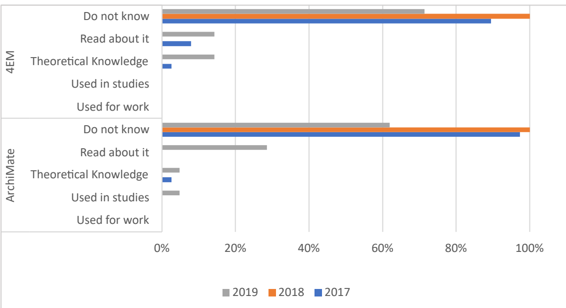

Figure 6: Students' previous knowledge of modelling methods (from the background questionnaire, the numbers are presented in percentage)

5.2 Feedback on the course

The students were asked to respond to a final questionnaire at the end of the course. This questionnaire was designed to understand students' modelling process and experiences as well as to receive feedback on the course. Responses from 2016-2018 have been analysed; 46%, 56% and 37% of those that completed the course, in 2016, 2017 and 2018 respectively; see figure 7. Unfortunately, the number of responses were low as the students tend to be very busy at the end of the semester and several students do not respond to tasks that are not mandatory. Note that due to an unexpected situation in 2019, there was no final questionnaire.

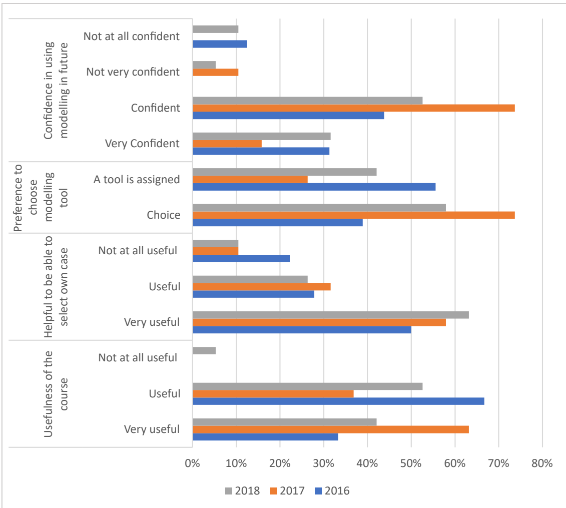

Figure 7: Feedback from the students (from the final questionnaire, the numbers are presented in percentage)

In general, the responses show that the students found the course useful or very useful. Two questions that directly relate to the pedagogical approach and the design of the course are about students' preferences in choosing their own cases to model and the choice of a modelling tool. When asked if they found it helpful to be able to select their own case or problem to model, the majority of the students found it useful (approximately 30%) or very useful (50-65%). Identifying a suitable case to model was a challenge to many students at the beginning of the course. The threshold for this activity was high as the students are, in most other courses, provided a problem which they have to solve and therefore they were not used to defining their own problems. However, once they had overcome the initial challenge, they seemed to appreciate the learning experience as shown by the responses. When the students were asked if they would prefer to have the choice of a modelling tool or be provided one, more students responded that they would like to be able to select their own modelling tool, although quite a lot also indicated that they would like a tool to be assigned to them. When the students were asked if they felt confident in using modelling in their future work, the majority of the students felt confident or very confident while only around 10% of the students responded that they were not confident and 10% responded that they were not at all confident.

5.3 Pros and Cons of 4EM and ArchiMate

The students were asked to explain in their reports, their reasons for selecting 4EM or ArchiMate as the Enterprise Modelling method to continue developing their models with. The explanations provided in the reports were analysed using QCA. The first step was to identify the main themes or categories of reasons and then structure them as pros or cons about each language. An overview of the pros and cons of the two modelling methods that were identified by the students are shown in tab. 2.

6 Criteria for selecting an Enterprise Modelling Method

The pros and cons identified by the students in describing their reasons for the choice of either 4EM or ArchiMate as the Enterprise Modelling language to continue enhancing their models provide valuable insight in determining a set of criteria to be considered when selecting an Enterprise Modelling method for educational purposes. Six categories of criteria have been identified and they are listed below:

1. Availability of a modelling tool or software application.
2. The ease of use.
3. Ease of learning and understanding the concepts and relationships.
4. Expressiveness of the modelling language.
5. Capabilities to model the technical aspects and components of an enterprise.
6. Ease of understanding the models for all stakeholders.

In the rest of this section, we will discuss why these criteria are relevant for the students' assignments and why we think they might have considered these criteria.

6.1 Availability of tools

The availability of a digital modelling tool that supports the Enterprise Modelling method is an important criterion when selecting an appropriate modelling tool. The physical quality identified in the SEQUAL framework highlights the relevance of this criteria, to externalize the contents of the model and to ensure its availability to others (Krogstie 2012). One of the main advantages of the ArchiMate modelling method is the availability of the Open Source software, Archi, which is free and available on the Internet (Beauvoir and Sarrodie 2021). Archi has a large user base and thus many example models are also available on the Internet. In addition, free online learning sources and documentation are also available for Archi and ArchiMate. The availability of information about a method has been identified by other authors also as an important criterion in the choice of a method, e. g. (Sessions 2007).

The 4EM modelling method, on the other hand, did not have a digital modelling tool that supported the method during the first years, and the students reported that there is inadequate tool support. This was identified as a major drawback of the method. Students were provided with modelling templates in Microsoft Visio. However, this proved to be difficult as most students needed to pay for a license to use Visio. Nonetheless, they found ingenious

Table 2: Pros and Cons of 4EM and ArchiMate

	Pros	Cons
ArchiMate	- Modelling Tool – availability of the "Archi" tool. - Strict syntax helps to maintain the same standard in all models. - Comprehensive language with several components. Good for complex models. - "Layers" makes the model easier to understand, provides better representation. - Gives a top-down approach, which helps to understand the model easily. - More components to present technical aspects than in 4EM. - Access to several free online learning resources and documentation. - Standardised and compatible with TOGAF	- Need to learn and have detailed understanding of the language. - Difficult to choose the right kind of relationships in the model. - The large number of components can also make it confusing.
4EM	- Easy to understand the language, even for beginners. - Easy to understand the models for the stakeholders. - Specific actors for each task can be modelled. - Concepts can be shown separately. - Easy to show the relationships among the elements. - Possibility to decompose entities or create sub-entities - Clear perspectives of enterprises - Cloud based or google based draw.io gives easy access to model files.	- Lack of dedicated tools for modeling in 4EM. - Lacks precise components for technology aspects. - Connecting all the sub-models is difficult. - Parts of the models may become redundant.

solutions to create their models; the most popular was draw.io, a browser-based diagramming application with cloud-based storage. The lack of a dedicated tool for creating 4EM models, particularly from 2016-2018, led to challenges in connecting the different aspects of the enterprise model (or sub-models such as the goals model or the process model), maintaining the consistency in the model and avoiding redundancy. One student expressed this as ‘another problem is that parts of the model quickly become redundant, as certain things have to be repeated, especially in the case of creating sub-models’.

6.2 Ease of use for modelling

A user-friendly modelling tool is desired and part of being user friendly is that it is easy to use by model builders. This can be related to desirable characteristics of modelling languages that have also been identified by other authors, such as simplicity (Halpin and Morgan 2008). The criteria easy to use was identified by the students as one of the pros of 4EM while several noted that ArchiMate was more challenging to learn. The main reason ArchiMate was more difficult for the students was the large numbers of objects and relationship types that were included in the ArchiMate modelling language, supported by the Archi modelling tool. This made it more difficult to use the language to create their models as well as communicate the model to the stakeholders. It also made them less confident of the correctness and quality of their models. However, one of the pros of the Archi modelling tool that was mentioned was the ‘magic connector’ capability for creating relationships among the entities.

6.3 Ease of learning and understanding the concepts and relationships

Proper et al. (2019) identified one of the challenges in learning to create enterprise models as the dual complexity of understanding and conceptualising the problem domain and representing it as a model. This dual complexity is further enhanced by the challenge of learning to use the modelling language and the tool. Furthermore, a user’s preference of a tool is also affected by how they perceive the modelling or diagramming language (Ong and Jabbari 2019), the clarity (Halpin and Morgan 2008), and the way of modelling such as the modelling concepts and the mechanisms for defining them (Bock et al. 2014).

A user-friendly modelling tool is easy to learn to use and to understand the concepts in the modelling language and how they may be used to best represent an enterprise. As reported in the literature, one of the challenges faced by novice modellers is the identification of the appropriate concepts and relationships (Rosenthal and Strecker 2019). This criterion is related to the criterion ease of use. However, as our user group consists of students (novice modellers) rather than experienced modellers or practitioners, we believe it is important to separate these criteria rather than consider them as a part of user- friendliness.

6.4 Expressiveness of the modelling language

The purpose of modelling (Kassem et al. 2011), the intended use of the model and the properties of the modelling objects (Bider 2005), the expressibility (Halpin and Morgan 2008), taxonomy completeness (Sessions 2007) and functional completeness (Fox and Gruninger 1998) have been identified in the literature as important criteria for selecting a modelling language. Furthermore, the ability to express the problem domain in the modelling language has been identified as an important criteria in a modelling language (Proper et al. 2019). In addition, the semantic quality of the SEQUAL framework identifies domain appropriateness as important for the appropriate representation of the knowledge on the domain (Krogstie 2012). It is indeed these criteria that determine the expressiveness of a language that the modeller, or our students, need for their modelling activity. While ArchiMate and 4EM have considerable overlaps and, in theory, they should both support modelling the same contents (Sandkuhl et al. 2014), the motivations for the methods are different and thus these differences are evident in the modelling languages. For example, the components to model goals and the technology are significantly different, although they complement one another very well. Thus, it can often be cumbersome and challenging, especially for novices such as our students, to use a method that is less appropriate for their cases. The models created by the students indicate that they had identified the differences and the complementary values in the two languages.

6.5 Capabilities to model the technical aspects and components of an enterprise

In the study by Sunkle et al. (2013), the authors mentioned '... economy of concepts and coverage of concepts pertaining to various aspects of enterprise' as a reason for choosing ArchiMate (Sunkle et al. 2013, p. 3). In the students' reports, we have seen that many students also mentioned that ArchiMate provided a broad range of concepts to model technical components and IT infrastructure, which in their opinion, was lacking in 4EM. The wide range of concepts to model technical aspects was considered as an important criterion for selecting ArchiMate over 4EM. For example, one student reflected in his report that '*4EM is lacking much precise modelling of the technology. It is more on to modelling the business logic and strengthening the ways to enhance the process of the business side. But ArchiMate has the variety to cover also the technology aspects like devices, infrastructure, process and functions*.' The capability to model technical aspects relates to the expressiveness of the language. However, since the students mentioned this aspect of the language explicitly, we have addressed this as a separate criterion.

The students' intended use of the model was related to the cases that they had chosen to model and the specific innovations and services they had identified to enhance their enterprise. This highlights the relevance of domain appropriateness of the modelling language, as also identified in the SEQUAL framework. A number of the cases that the students have chosen to model included digital innovation and digital services and hence the need for modelling technical components could be appreciated. Although the capabilities for modelling technical components is encompassed within the criterion expressiveness of the modelling language, it is perhaps important to highlight criteria that may be important for specific modeller groups or modelling purposes, as in the case of these students taking a course within a Department of Computer Science.

6.6 Ease of understanding the models for all stakeholders

The pragmatic quality is defined by the SEQUAL framework as related to the comprehension of the model by the modelling participants and the stakeholders (Krogstie 2012). Modelling is a participatory process; involving the stakeholders and experts is a basic element of 4EM (Sandkuhl et al.

2014) and ArchiMate, which is designed to support the TOGAF ADM process (Josey 2018), assumes the involvement of at least the management, business managers and IT managers in organisations. In the final questionnaire at the end of the course, the students were asked if they had shown their models to the real customers and stakeholders. 44.4% (in 2016), 21.1% (in 2017) and 36.8% (in 2018) of the students responded that they had. Considering that the cases were chosen by the students based on their own experiences, and most of them had selected cases based on their working experiences, it is safe to assume that they were consciously thinking of the real stakeholders. This assumption is confirmed by one of the students as follows: '*Considering the target of the report I ended up choosing 4EM. Mainly because it is easier for the target user to understand it*'. This statement was also confirmed by other students, and they explained this as a reason for selecting 4EM, as it has a simple syntax and is easy to understand. While modelling, the students also considered that all their stakeholders may not have prior knowledge of Enterprise Modelling. So, at least the students who claimed that 4EM was easy to understand assumed that the stakeholder would also find 4EM easy to understand and to provide feedback about the models.

7 Discussions and Recommendations

Criteria related to user-friendliness (ease of use and easy to learn and understand) appears to be most important to the students. The students were learning what Enterprise Modelling is about, the modelling concepts and how to use the methods and the associated tools simultaneously. The cognitive demand on the students was high and thus it is not surprising that these criteria reigned high among the students. The students' reports indicate that they started modelling with the method they found easiest or simplest, which may have helped them understand the concepts better, equipping them better to tackle a more difficult or complicated method and language.

The criteria identified by the students may be different from the criteria that a practitioner may consider and are important when an organisation selects a modelling method; e. g. criteria identified in the literature such as (Bider 2005; Bork and Fill 2014; Kassem et al. 2011). Modelling in real world organisations need not only consider methods that are flexible and easy to create models with, but also ones that are easy to update and maintain (Fischer et al. 2007) and promise their availability over a long time or the possibility to migrate the contents of the model easily. A few students noted that standardisation of the modelling language was relevant and that one of the pros of ArchiMate was its compliance with TOGAF. Interestingly, a few students who chose 4EM as the modelling language for the final part of their modelling tasks chose to structure the model according to the TOGAF layers. The students' reference to standardisation of the modelling language could be ambiguous; since TOGAF was taught as a part of the course and many had structured their models, including their 4EM models, using the TOGAF layers, it could be assumed that they would like the language to support a (defacto or other) standard such as TOGAF. This, however, raises an interesting point which relates to the discussions in the literature on the standardisation of enterprise modelling languages and balancing with the pragmatics of modelling and the needs from the specific domain of application (Bjeković et al. 2013).

It is interesting to note that the criteria that the students have identified did not always address the long-term perspective or indeed the lifecycle of the model or the evolution of the enterprise architecture. However, criteria related to user-friendliness and expressiveness of the modelling language are aligned with the criteria identified by other researchers too; e. g. (Proper et al. 2019).

Some of the literature on selection criteria and comparison frameworks for modelling methods provide meta-analyses of criteria and how one criterion may affect another; e. g. Bock et al. (2014) notes 'ease of use vs. expressiveness of the language'. We also identified relationships across the criteria identified by the students and discussed in sect.6; e. g. the criteria ease of use and ease of learning and understanding the concepts and relationships are related. Similarly, the ease of learning and understanding is also related to the expressiveness of the modelling language and its appropriateness to the domain of interest. And more importantly, when modelling enterprise architecture, the expressiveness of the modelling language relates to the capabilities to model the technical aspects and components related to an enterprise.

The selection criteria that could be identified from the students' assignments provide insights to students and teachers of Enterprise Modelling methods. The recommendations for teachers and students are summarised in the following paragraphs.

From the teachers' perspective, 4EM and ArchiMate were chosen because they provided the modelling constructs that were required for the course and also due to their differences, which exposed the students to a wider spectra of Enterprise Modelling languages. Furthermore, they were preferred because of their ease of access and availability, which is also one of the criteria that the students used for selecting a modelling tool. Two of the selection criteria for the students were the ease of use, and the ease of learning and understanding. This raises a dilemma for the teachers to determine if they should always choose the modelling tool that the students perceive as easy to use and learn, in all circumstances. For example, a tool that is less easy to use and learn may include important concepts that the students need to learn. In the case of 4EM and ArchiMate, both the modelling languages included the relevant concepts and structures and, hence, this was not an issue.

Similar to students' preference of a tool based on the ease of use, learning and understanding, it was important for us as teachers to also consider what would not only be easy to learn and understand for the students, but also what made it easy to teach Enterprise Modelling. From this perspective, despite the differences in the motivations for the two approaches and the way they are structured, the approach to teach them did not appear to be very different. It is important to note that we have not systematically studied the best way to teach these languages, nor have we conducted a study among other teachers of Enterprise Modelling or the specific languages and therefore these are based on the experiences of the authors only.

7.1 Recommendations for Teachers

The dual complexity of understanding and conceptualising the problem domain and representing it as a model, as identified in (Proper et al. 2019), increases the cognitive load on the students. Moreover, Rosenthal and Strecker (2019) identified cognitive challenges faced by students learning conceptual modelling, some of which could be related to the choice of a modelling tool. Cognitive Load Theory addresses the concerns when learners are faced with an overwhelming amount of content that needs to be processed simultaneously and designing the learning at an optimal level of complexity to reduce the load on the working memory, to foster learning and to achieve the learning objectives (Gog et al. 2010). One of the main challenges for teachers of Enterprise Modelling is to manage this aspect of the learning design and therefore, understanding the perspectives' of students and their needs can provide insights that could help teachers design better learning activities. Given the limited research in this area, the feedback from the students, such as their criteria for selecting modelling tools, could inform the decisions made by teachers in selecting an appropriate modelling tool as well as designing the learning activities. Hence, for teachers, choosing a method that is easily accessible; user friendly (i. e. easy to use, easy to understand and easy to learn to use), is important. However, this raises a dilemma in selecting an appropriate modelling language that is both easy to use, learn and understand from the students' perspective as well as one that is appropriate for achieving the learning outcomes of the course. Teachers are recommended to carefully weigh out the options to make the best choice to achieve the learning objectives. Furthermore, this implies that it must also be easy for the teacher to introduce it to the students, with the appropriate steps and scaffolding that helps the students build their knowledge effectively. An appropriate method and modelling language for the intended use of the model is also important not only to result in a good model, but also for the effectiveness of the learning. This exercise has also highlighted the value of not isolating the teaching and the task to one modelling method or language, but to support the students to appreciate the complementary role and mutual value of Enterprise Modelling, and indeed that of a specific method, within a landscape of several methods.

For the students, user friendliness, i. e. easy to use, easy to understand and easy to learn to use, appears to be an important criterion. If there is a choice of modelling methods, students could be recommended to start modelling with what they find easiest or simplest. This can help build their understanding of the Enterprise Modelling concepts as well as their confidence in modelling. It is then easier to consider the expressiveness of the language or the appropriateness of the language for the intended purpose of the model.

It is important to note that this course was for Masters students, who were novice enterprise modellers and had limited practical experience in organisations and analysing enterprise business situations. Hence, the course was designed to teach students the theoretical concepts and to help them apply these concepts to real or realistic enterprise situations. The learning goals and expected learning outcomes would no doubt differ for different student groups. If the student group was from the first two to three years of their university studies, the course may be designed with a lesser cognitive load for the students, e. g. provide them a simple, but realistic case that they could all relate to and perhaps focus on a single modelling language. If the students were practitioners or people with business experience, the teaching approach would most likely be different and may have to be adjusted. In this case, the choice of a modelling tool may be influenced by the students' familiarity of a specific tool or the specific business needs.

8 Summary

Innovation in enterprises require an understanding of the inherent complexity and dependencies among an enterprise's processes, goals, resources, customers and several other aspects. The choice of a suitable Enterprise Modelling method is an essential part of it. There is a large number of Enterprise Modelling and Enterprise Architecture methods, and comparisons of different methods are reported in the literature. However, the literature on selecting or determining an appropriate modelling method for novices or for educational purposes is limited. Thus, the main motivation for this paper is to share students' perspectives from a course in Enterprise Modelling and Enterprise Architecture, for the benefit of students and educators. The main contributions of this paper are a set of selection criteria and recommendations to help students and teachers select modelling methods and languages, for educational purposes.

The results reported in this paper are based on a university course on Enterprise Modelling and Enterprise Architecture, over four years, where students were asked to create models using two modelling methods and languages, 4EM and ArchiMate, and then select one of them to continue enhancing the model. The students' perspectives on the Enterprise Modelling methods are presented as a set of pros and cons and as a set of selection criteria. The paper discusses these criteria and provides recommendations to students and teachers in selecting modelling methods and languages for novices and for educational purposes.

The contributions reported in this paper are based on students' responses to questionnaires and a post hoc analysis of the reports submitted by the students as a part of the examination for the course. The analysis of the students' reports has also provided insights into the students' enterprise modelling processes and challenges related to learning enterprise modelling. We plan to obtain more specific data in the future, through questionnaires and other means, to conduct an in-depth analysis. Furthermore, the material related to the courses and the students' responses to the surveys also provide valuable feedback related to the pedagogic approach and the specific learning activities such as presentations and group discussions. We are currently conducting interviews with students about group activities to gain a deeper insight into the role of group presentations and peer feedback in their learning process and how such learning activities are beneficial for learning Enterprise Modelling.

An education approach driven by students' satisfaction and the need for engaging students in their learning activities, the Action Research approach for the continuous development of the teaching practice and knowledge has been beneficial. The Action Research based approach has guided the teachers over the years and ensured a continuous improvement of the course based on their experiences and the feedback from the students.

The QCA approach has been used to analyse the qualitative data. One of the limitations of this study is the low proportion of the students that responded to the final questionnaire at the end of the course each year. Similarly, the rigour of the QCA could be improved to obtain more detailed insights into the students' choices and to understand better their specific challenges and needs. We aim to continue analysing the material from the courses to better understand the students' challenges and motivations, and to continue enriching the data and to share our insights with the Enterprise Modelling community in the future.

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