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Educating Engineer Students Business Models: Exploring a Proposed Framework to Capture Business Model Dynamics

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***Abstract*— Business model innovation and Business Model Canvas, as well-known business model architectures, have gradually become an essential topic in entrepreneurship education. The application of Business Model Canvas is considered an effective and reliable unit of analysis to measure companies business operations and performance. It helps students to first analyze the Business Model Canvas of an existing business and then create their own business idea. Although the Business Model Canvas helps students to get a quick view on the business operations through the creation, delivery and capture of value, in practice, entrepreneurs need to adapt and change their business operations constantly in order to grow and remain viable. Considering the need to capture the business dynamics in business model framework, the aim of this paper is to propose a dynamic business model framework as an alternative tool. Engineering students at Delft University of Technology were asked to critically assess the limitations of the existing business model canvas, and then students gave input and assessed an alternative dynamic business model. The results show that the current Business Model Canvas cannot capture the business model innovation of companies and the proposed framework improves student's understanding of business model innovation and in particular their dynamic nature.**

I. INTRODUCTION

Scholars have highlighted that technology education needs to focus more on "innovation and entrepreneurship" components, with anticipated outcomes of education programs geared toward "organizational renewal and new-venture creation" [1]. Innovation and entrepreneurship components in education prepare students to find or create jobs in today's knowledge-based economy. Entrepreneurship education can positively influence the societal impact of engineering education by bringing new technologies into the market [2],[3]. However, the education programs for teaching engineering students is primarily focused on technical training, and in general, does not help them to develop new business initiatives [4]. In recent years, more attention is given to include business related subjects in educational programs for engineering students, yet these subjects aim at developing business plans by making use of tools such as the business model canvas (BMC) [5]. These approaches do not focus on the development process of business which is in line with recent studies that questioned the traditional approach of entrepreneurship education on writing business plans [6]. and argue to focus more on recursive interaction, which reflects the unique process of crafting business models [7]. BMC as a well-known business model architecture, has gradually become an essential topic in entrepreneurship education [8].

Students are typically taught to first analyze and summarize the business model of an existing business, then create their own business idea. However, the BMC has many limitations, for example, the static representation of the BMC has contributed to the loss of its dynamics and the information that comes with it [9]-[15]. The business model, is no longer seen as a description of the logic of the firm in a static manner: rather, it constitutes a device that can describe and shape the development and change processes taking place within both established firms and new ventures [16] by looking across time [17]. This approach helps to create a mindset among students that nurtures them to think and align with the dynamic nature of business and start-ups. The notion of business model dynamics is attracting an increased number of theoretical perspectives (e.g., [18], [19]).

Khodaei and Ortt [19], proposed the following four criteria to assess the degree of dynamics in any business model frameworks: 1) completeness of business model aspects, 2) interrelationships between aspects, 3) interrelationships over time, and 4) framework changes over time and across contexts. In a recent study, Kamp et al. [20], developed business model dynamic framework based on these criteria by focusing on the business model elements changes (the value proposition, the value network and the value capture) as well as external and internal factors and business model consistency. This paper seeks to describe and apply this proposed business model dynamic framework [20] to explore: How can we teach business model Innovation through business model dynamic framework to help engineer students to better understand and apply the business dynamics of companies? To address the question, we collected data from 370 engineer students between 2021 and 2023 who participated in "Technology Entrepreneurship and Innovation" course offered at Delft University of Technology at master level, through semi structured survey. First, students were asked to reflect on the business model of the existing startup by using business model canvas and then critically evaluate and analysis its limitations. Second, they were asked to apply the business model dynamic framework and evaluate the framework based on the dynamic criteria as well as the pedagogical objectives of the course modules on business model innovation. The results show that the current BMC cannot capture the business model innovation of start-ups. However engineer students valued the proposed dynamic business model framework by helping them to better understand and apply a business model of start-ups and to understand and reconcile the business model dynamic. Therefore the study contributes to a recent call to examine the

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effectiveness of current business model frameworks such as business model canvas [4]. Moreover from an analytical point of view, our research contribute to Greene and Rice's [21] and Fayolle's [22] call for deeper insight into the evaluation of entrepreneurship education methods by questioning the effectiveness of a new method for introducing entrepreneurship related to "what" we teach, "how" we teach and "for what" we teach (learning objectives) [23].

More detailed explanation is given in Section 2 discussed the critics of using BMC and foundation for our proposed framework. Next, Section 3 presents the materials and methods used for data collection. Section 4 presents the results and Section 5 shows the discussion, conclusions, including implications and limitations of this study, proposing future lines of research.

II. LITERETURE REVIEW

A. Business Model as one of the Cores of Entrepreneurship Education

Among the various aspects of entrepreneurship, entrepreneurship education often focuses on "entrepreneurship basics", which includes some core content such as the entrepreneurial process, innovative business models, lean start-up thinking, entrepreneurial orientation and entrepreneurial cognition, among others [24]. Common across entrepreneurship education is its focus on the search process for the opportunity [25]. It involves the search for the product-market fit and adapting the key operations along the phases of growth to sustainability [26]. Hence, entrepreneurship is not static, which requires that entrepreneurship education be vigilant in teaching and with an aim to apply frameworks and principles that bring rigor, logic and realism to student thinking and acting [27]. The business model, as a practical concept to analyze the business operations, is a promising tool to shape a more challenging environment for teaching students entrepreneurship [23]. Based on the definitions by Amit and Zott [28]; Johnson et al.[29]; Magretta [30]; Osterwalder and Pigneur [31]; and Teece [32], business models are simplified representations of the elements - and interactions between these elements - that an organisational unit chooses in order to create, deliver, capture, and exchange value. In particular, Leschke [6] pointed that business models is useful for introducing entrepreneurship to nonbusiness students. Several attempts have been made to create visual descriptions of business model components.

One of the main frameworks that entrepreneurship education teachers use to teach business models is the Business Model Canvas (BMC), a well-known framework, used to understand the way in which an organization creates, delivers and captures value [33]. The BMC has been widely used in entrepreneurship programs, start-ups and large companies as a user-friendly approach to business modeling [25].

B. Model Canvas and its Criticisms

Business model canvas is a well-known framework by Osterwalder and Pigneur [5], which presents how an organization creates, delivers and captures value from a product or service by presenting nine elements: Value Proposition, Segments, Customer Relationships, Channels, Key Resources, Key Activities, Partners, Costs and Revenues [31]. BMC is known as one of the most cited classifications that represent the critical components responsible for detailing a business model [34]. While the aim of the BMC is to picture clearly the way in which a business creates, delivers and captures value, several limitations concerning the BMC are identified and are divided into several categories:

1) Excluding a notion of competition; There is no broad analysis of competition, although every decision about competition and competitors are crucial for every business model [35], [9], [36], [11].

2) Excluding key performance indicators; Entrepreneurs must focus on the key performance indicators they aim to work with [35], [9].

3) Lack of business goals; The current version of the Business Model Canvas does not take into account the strategic purpose of companies in terms of their mission, vision, and strategic objectives [9], [11], [36].

4) Applicability and suitability of BMC in different context; The academic study and startup practice of businesses in China and other Asian countries are different with ones in the Western model archetype, because the entrepreneurial ecosystems in these countries show significant distinctions compared to the West, therefore the current version will not apply to such context [37], [38].

5) Mixing levels of abstraction; Not all of the nine Business Model Canvas elements are defined at the same level of abstraction. The components 'customer relationships' and 'channels' on the right side as well as 'key activities' and 'key resources' on the left side are on a different level of abstraction than other parts [11],

6) Problem/solution issue; It is too difficult to find the real problem first in order to build the right product or service to solve it [35].

7) Focusing on financial value; Although the original definition of a business model is centred around the notion of value, it is implied that financial value is the only dimension of value that is measured in a business model. This cannot be true for social enterprises, NGOs, etc. [11], and [39].

8) Lack of coherence: Euchner and Ganguly [12] argue that the Business Model Canvas does not represent well the coherence or relationships among the elements.

9) Too broad: De Reuver et al. [40] note that the BMC simplicity is both a strength, because it is readily applicable, and a weakness because it provides little detail about each variable. Although the concept of BMC has achieved the goal of simplicity, some issues of the BMC have been put forward since some key points of a business model are missing in the BMC [41].

10) Complexities: Gunzel and Holm [41] mention that the multifaceted structure of the BMC may create "perplexities and complexities" in the business model innovation process. There are also key fundamental differences in the expectations, experiences and objectives between different practitioners using the BMC (i.e., entrepreneurs and managerial intrapreneurs). For example, Keane et al., [42], interpreted priorities and business factors in the BMC differently for entrepreneurs "(1) Finance and

Operations and (2) Serving Products to New and Existing Customers," and for managers "(1) Making Products and Serving them to Existing Customers and (2) Costs and Revenues."

11) Negative impact on creative thinking; Eppler and Hoffmann [43] found that it could also have a negative impact on perceived creativity during the ideation process due to the fixed structure of the template.

12) Too static approach; the current version of Business Model Canvas does not reflect the entire complexity of the model and requires a supplementary methodological support to better frame a dynamic complexity [9]-[15], and [19].

The BMC framework is a static representation of the business organization without revealing how different elements of business model changing over time. Start-up companies that aim to develop and introduce radically new high-tech products in the market have to cope with a dynamic, mainly turbulent, internal and external company environment. As a result, their business models should constantly be adapted and changed to cope with this environment. In order to trace the origins of business model innovation and track effects, students require business model frameworks capturing dynamics [44].

This is our approach to improve the BMC following the lack of dynamic perspective with the last critique as the most important and central problem of BMC based on two lines of reasoning. The 'too static approach' of business models has been mentioned by most of the authors. Second, most of the other criticisms mentioned as the BMC are somehow related to the lack of the dynamic perspective of the Business Model Canvas. For example excluding external factors such as competition and lack of strategic purpose both have dynamic aspects. These criticisms should be taken very seriously specially in the case of high-tech start-ups that need to survive in such highly turbulent environment. These start-ups must change and adapt to internal and external changes which impact their business and their business models. Unfortunately, the static representation of the companies has contributed to the loss of its dynamics and the information that comes with it.

C. Business Model Dynamics

Business model dynamics literature has gained significant interest over the last years [45], assigning to business model innovation [28], Business model adaptation [45], business model renewal [45], and business model evolution [46] [19], p. 201 define business model innovation as 'designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements'. Demil and Lecocq [46], p. 239 define business model evolution as a 'fine-tuning process involving voluntary and emergent changes, in and between permanently linked core components' in response to both external and internal factors. According to the extant body of literature, business model dynamics refer to "how business models come into being (…) and the changes in the architecture between business model elements that produce alterations to the business model" [19], p. 17, as well as "shaping, adapting and renewing the underlying business model of the company" for sustained value creation [47]. As business models are constantly subjected to re-evaluation for the firm to navigate through a changing environment to produce sustained competitive advantage [32]. Therefore the business model, is no longer seen as a description of the logic of the firm in a static manner: rather, it constitutes a device that can describe and shape the development and change processes taking place within both established firms and new ventures [16] by looking across time [17], leading their conceptualization from a phenomenological perspective. Business model dynamics encapsulate the prospective character of the business model concept, highlighting its role as a market device that enable firms to evaluate and validate the future value creation and capture potential it will entail [16]. Business models should deal both with gradual and predictable trends and with sudden, unpredictable and disruptive events. Gradual and predictable trends can be previewed and hence can lead to business model dynamics that take these trends into account.

D. Dynamic business model framework criteria

Khodaei and Ortt [19] employ four criteria to evaluate the level of dynamism in business model frameworks:

1) Completeness: This criterion involves considering both internal company aspects and external environmental aspects to ensure a comprehensive understanding of the business model.

2) Interrelationships Between Aspects: Assessing the connections between different aspects is crucial for gauging the coherence of the business model. This coherence is seen as a indicator of the buisness model's overall quality.

3) Interrelationships Over Time: Understanding how the various aspects of the business model interact and evolve over time is essential for grasping the dynamics of business model evolution.

Framework Changes Over Time and Across Contexts: Business model frameworks must be adaptable over time and across different contexts. This adaptability ensures that frameworks remain both simple and useful while still capturing the complexity of the business environment. Table I presents the summary of business model dynamic's criteria.

TABLE I. BUSINESS MODEL DYNAMIC FARMEWORK CRETERIA SOURCE, [19]

CRITERIA	Degrees in which criteria can be met
1. Completeness	a. Not Complete variables
	b. Completeness assumed but not specified
	c. Completeness specified
2. Interrelationships	a. No interrelationships distinguished
	b. Relationships assumed but not specified
	c. Relationships specified
3. Interrelationships over time	a. No interrelationships over time distinguished
	b. Relationships over time assumed but not specified
	c. Relationships over time specified
4. Framework changes	a. No framework changes distinguished
	b. Framework changes assumed but not specified
	c. Framework changes specified

By employing these four criteria, Khodaei and Ortt [19] aim to provide a comprehensive assessment of the dynamic nature of business model frameworks, taking into account their completeness, coherence, evolution over time, and adaptability across various contexts.

E. Dynamic business model framework

The aim of dynamic business model framework is to capture business model dynamics into a comprehensive framework. Such framework should reflect on the previous dynamic criteria such as capturing various origins of changes as well as various types of changes in business models elements in order to keep business model consistency. Kamp et al. [20] presents a dynamic business model framework following previous dynamic business model criteria by Khodaei and Ortt [19].

The framework is composed of three main elements: the value proposition (VP), the value network (VN) and the cost and revenue stream (CRS). Concerning completeness, Kamp et al. [20] captures environmental factors that influence the Business model variables. The framework characterizes these factors by external (E) or internal (I) origins and threat (T) posed or opportunity (O) provided. Simultaneously, the framework classifies interrelationships according to whether they are forced changes (F) or strategic choices (C). The last two criteria are accomplished by representing changes in all directions of interrelationships on a time axis. Using this framework, the categorization of origins of changes in business model elements due to external and internal environment variables can be subdivided by their types (external/internal). The interrelationships between different business model elements can also be seen (forced change/ strategic choice) (see Figure I).

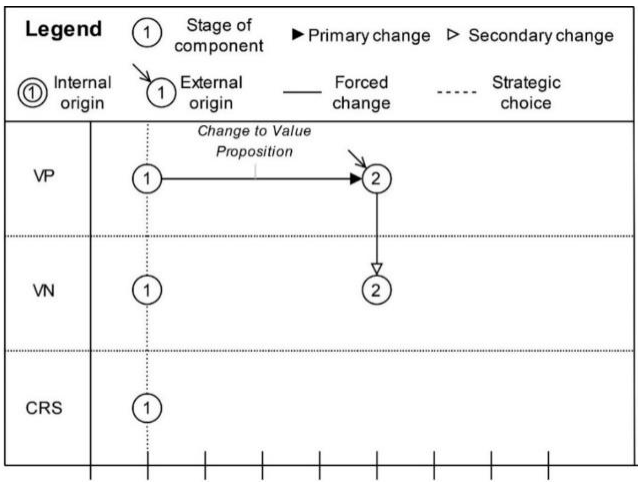

FIG I. THE DYNAMIC BUSINESS MODEL FRAMEWORK: EXAMPLE – VALUE PROPOSITION (VP) CHANGE WITH EXTERNAL ORIGIN LEADING TO FORCED VALUE NETWORK (VN) CHANGE .SOURCE, [20].

Kamp et al. [20] model developed based on six consideration: (1) The business model is divided into three key components: the value proposition, the value network, and the cost and revenue structure; (2) Change can originate from within or outside the company; (3) Initial changes in the business model target a specific element; (4) Ensuring business model consistency typically necessitates subsequent changes in one or more other elements; (5) The initial alterations are termed primary changes, and any subsequent adjustments are referred to as secondary changes; (6) Business model changes may be either forced or strategic choices. These six key considerations are integrated into a unified framework, as illustrated in Figure I.

The framework visually represents how changes trigger further changes. In Figure I, an example is depicted: a modification in the value proposition (originating externally) results in a change in the value network. The arrows in Figure 1 denoting these changes are solid, indicating that they signify forced changes. Therefore, following the initial forced changes in the Value Proposition (VP), the Value Network (VN) is forced to change as well.

III. RESEARCH DESIGN

To elaborate theory about how to teach engineering students to understand and be able to analyse the dynamics of new startup development we assess the existing Business Model Canvas (BMC) and the proposed Dynamic Business Model Framework The assessment of the models is done by engineering students that participate in the course "Technology Entrepreneurship and Innovation" offered by the Delft Center for Entrepreneurship at Delft University of Technology. This course runs every quarter and covers theoretical and practical basics of the entrepreneurial journey of a technology-based startup. Using theoretical models, the students analyse and reflect on the early growth and development process of a real startup. Specific interest is put on the changes of the startup's business model, such as in product development, collaboration, market entry and revenue model.

As part of the major assignment in this course, students are asked to reflect on the business model of the startup, by applying the BMC and they critically evaluate the logic of the startups business model and they also reflect upon the limitations of the BMC. In the second step, the students are asked to apply the Dynamic Business Model Framework to describe and analyse the changes in the startup's business model The course assessment is then based on the extent that students are able to apply the theoretical models to describe and analyse the business model of the startup and how they argue and offer recommendation to the startup regarding their business model for the next years. The course is taught annually over the last five years in every quarter at master level.

3.1 Data Collection

Our analysis relies on multiple sources of data. For the first part of study on the Business Model Canvas challenges, we rely on more than 100 teaching hours delivered from 2016 till 2023 to over 550 students, written and oral material based on student projects and presentations during the course, as well as students' written evaluations of the tools and oral feedback transcribed by the instructor. The second part of study, as the evaluation of the business model dynamic framework, data was collected from 370 master students through questionnaires, which were filled out during the last weeks of course over the last 4 quarters.

3.2 Data Analysis

A) Evaluating the Current Business model canvas

For the first part of our study, we followed the principles of grounded theory to generate a plausible and

useful theory about business model dynamic framework education. We follow this methodology because the previous studies did not reveal existing theory on the use of business model frameworks for education of engineers [4]. We progressed from a very detailed reading and analysis to greater generality in three analytical steps. First, we performed thematic analysis based on the instructor's course notes, student feedback, and course evaluations and several open questions regarding business model canvas critics using a large set of data-based "open codes" [48]. We then searched for underlying meanings and relationships between codes and different levels of themes, or "something important about the data in relation to the research question" [49], p. 88. Table II depicts the coding structure.

TABLE. II CODING STRUCTURE FOR BMC CRITICS

First-order codes	Second-order codes	Aggregate categories
Absence of competences	Not complete in internal variables	Lack of completeness
Absence of company strategy		
Absence of company vision		
Absence of technological factors	Not complete in external variables	
Absence of environmental factors		
Absence of competition		
Absence of social and environmental values	Not complete in business model variables	
No specification of industry		
Absence of relationship between one block and another block	No one-one relationship	Lack of Interrelationships
Absence of relationship between one block and other blocks	No multiple relationships	
Absence of relationship between all blocks	No holistic-consistency	
Lack of considering effect of external factor on block change	No change in blocks overtime	Lack of change over time
Lack of considering effect of changing in one black on another block		
Lack of considering effect of changing in one black on other blocks		
Lack of considering effect of changing in one black on other blocks	No change in the interrelationship over time	
Lack of alignments of interrelationships	No change in the multiple interrelationships	
Lack of flexibility for adding new blocks	Not consideration of new blocks	Lack of framework change
Lack of flexibility for adding new relationships	Not consideration of new interrelationships	
Lack of new alignments with all the interrelationships	No consistency with new blocks and multiple interrelationships	

The initial coding process began by analyzing the codes of the collected data, which yielded 19 categories after subsequent re-coding of the data. By identifying the relationships between these codes, 12 second order themes were then identified. Finally, those themes were generalized into 4 aggregate themes at a higher level of abstraction [49], [50].

To ensure reliability and credibility of the results derived from the coding process, we conducted an investigator process among the authors [51]. The authors were asked to review the coding structure to ensure the entire coding process was credible. Then, the proposed Dynamic Business Model Framework was developed based on the obtained themes and dimensions.

For example, we interpreted comments such as "you cannot see the interrelations between the different boxes example it's not clear how key activities can be accomplished by different partners" to indicate a challenge of lack of interrelationship between blocks of business model canvas. We compared findings to the current literature on teaching engineers [52] in order to refine our understanding, and achieving to a close match between theory and data. .

B) Evaluation proposed business model dynamic framework

For the second part of the study, we proposed students to use the business model dynamic framework and asked them to apply and illustrate the dynamics of the business model in the case of technology based start-ups. We asked them to work on a dynamic business model and capture the dynamics of business model in the course of time. The tool is based on the dynamic business model framework as published by Kamp et al. [20], which was built based on dynamic business model framework criteria as discussed by Khodaei and Ortt [19].

We challenged them to present the dynamic business model applying the Business model dynamic framework criteria to present dynamic business model of the company. Students were asked to work on online platform of Miro. This software allows communication to take place in the classroom with a basic set of features to improve the experience of collaborative work and provide a group discussion in "Miro board with Miro online post-it board. The possibility of sharing and simultaneous joint editing of text documents, or calculation spreadsheets, is a valuable asset of online collaboration work as well as steps and instructions. Therefore the teaching was organized in two phases in studies: (1) presenting and analyzing the proposed frameworks for business model dynamic; and (2) coaching students to apply frameworks the existing cases of technology based start-ups and evaluate the tool accordingly. We asked students to assess the proposed business model dynamic framework based on Hsu et al. [53]. They propose objective design criteria for learning platforms and develop an evaluation scale for learning platforms in which four dimensions and their respective indicators should be taken into account. These dimensions include instructional strategy, teaching material (accuracy, topic clarity, appropriateness, etc.), learning tool (usability, navigation design, etc.) and learning interface (text, image, animation, video, etc.) (see Table III).

We assessed these criteria with 7-point Likert scale questions (from "I do not agree at all" to "I totally agree"). We assessed the pedagogical objectives previously defined, known as Bloom's taxonomy. We also tested the utility of the application in visualizing a business model, communicating a business model and being convincing. The quality of an application also depends on using criteria that we split into three dimensions. Design, organization and user-friendliness

follow Hasan and Abuelrub's [54] comprehensive framework.

TABLE III. THE EVALUATION CRITERIA FOR BUSINESS MODEL DYNAMIC FRAMEWORK

Learning Objectives and Teaching Material (n=370, Disagree=1, Agree=7) Item description	Mean	SD
The business model dynamic framework helps me in better understand the business model dynamics of the company.	5.1	2.1
The business model dynamic framework helps me better illustrate and communicate the business model dynamics of the company.	5.9	1.3
The business model dynamic framework helps me in better applying the business model dynamics of the company.	5.8	1.4
User-Friendliness (n=370, Disagree=1, Agree=7)		
The tool has clear instructions for using its different parts and is easy to navigate.	4.9	1.6
The tool facilitates interaction between team members and develops teamwork.	4.1	1.9
Structure and design (n=370, Disagree=1, Agree=7) Item description		
I can easily add, edit text and choose the layout	4.8	1.6
It is easy to export the final document	4.9	1.7
The design of the application (images, text, graphics and animation) is appropriate	5.1	1.4
The new business model dynamics framework meet the dynamic criteria (n=370, Disagree=1, Agree=7)		
Completeness	5.3	1.6
Interrelationship	5.4	1.5
Interrelationship over time	5.5	1.5
Framework change	5.4	1.5

IV. RESULTS

The first part will discuss the findings from the thematic analysis of open question regarding to the Business Model Canvas (BMC) critics where the critics assigned into four categories as lack of completeness, lack of interrelationship, lack of change over time, lack of framework change. In the second part, the results show the findings from students assessment of the proposed Dynamic Business Model Framework based on the business model dynamic framework criteria as well as the pedagogical objectives of the course modules on business model innovation.

A. Business model canvas critics

The first part will discuss the findings from the thematic analysis of open question regarding to the BMC critics. The results show that the critics can be assigned into four categories as lack of completeness, lack of interrelationship, lack of change over time, lack of framework change.

1) Lack of completeness: Completeness of the business model is a key criterion for dynamics. Dynamics cannot be fully captured if important environmental variables that impact the business model variables are omitted, or when important business model variables that reflect strategic responses to changes in environmental variables are not included [19]. A business models "as sets of structured and operational relationships" between a firm and its internal and external stakeholders" [55].

The results indicate that lack of completeness were indeed links to the three categories of not complete in internal and external variables as well as business model variables. The external variables where related to absence of technological and environmental factors and absence of competitors, whereas internal variables include absence of competences, absences of company vision and strategies. The absence of competition is also confirmed by previous studies [35], [9], [36], [11]. Absences of company vision and strategies were also pointed by students which was mentioned as weakness of BMC by several researchers [9], [11], [36]. The effect of technological factors was mentioned by many students as one of them point: *"External factors which influence the business model are not shown, like for example technology development*".

Students also pointed to the absence of environmental and social values as well as specific sector consideration that make business model complete in elements. The absence of environmental and social values was mentioned by many students as one point: *" It does not take into account any sustainability and social values. This means that sustainable development goals are not taken into account, when they should be".*

Also students point to the must for design business model that can also apply for specific sectors like heath care which required more complex as well as complete business model variables. As one point: "*The customers in health care segment are diverse, so the value proposition for each customer is different, however these differences are not represented."* And the other claim: *"Leaves out key elements in healthcare for example in. medical industry it does not distinguish the user from the customer."*

2) Lack of Interrelationship: The capability to identify and assess the interrelationships between variables is another key criterion for dynamics. Distinguishing between environmental variables and business model variables is a categorization that implies a kind of interrelationship. The findings show that there are three types of relationships as one-one relationship, multiple relationships and holistic or consistent view of all the blocks A complete and static model does not specify such interrelationships and thereby does not incorporate knowledge of consistent business model [19]. A business mode is "containing cause and effect relationships" [56]. It is "a system of interdependent activities that transcend the focal firm and spans its boundaries" [57]. As the students point: *"the interrelations between the different boxes are not there, for example it's not clear how key activities can be accomplished by different partners".*

This is in line with Euchner and Ganguly [12] argument that the business model canvas does not represent well the coherence or relationships among the elements.

3) Lack of change over time: The capability to adapt and modify interrelationships over time is another key criterion for dynamics. Knowing cause and effect relationships helps to explain dynamics. Knowledge of variables that affect each other over time (without being able to distinguish cause and effects) allows for the explanation of more complex dynamics *[19]*.

Based on the data analysis the three aspects of changing over time are related to the change in the blocks, change of

interrelationship and change in all interrelationship as holistic change overtime which leads to consistency.

In terms of change in the block, findings point to the effect of external factors on block change, change in one block on the other block, and change of one block on the all blocks. Among these element the effect of external factors on relationship was highly mentioned as one point: *it's not explained how new technologies would affect new value proposition(s)*. This is also aligns with the discussion of adaptive business model, which reflects the active managerial process of harmonizing the firm's business model with a shifting environment, encompassing changes in customer preferences, supplier bargaining power, technological advancements, competition, and other relevant factors (Saeibi et al., 2017). This indicates not only the external factor but also the change in blocks will lead to changes in other blocks and to new interrelationships in business model. This is was pointed out by one student as: *" changing the value creation will lead to change in new revenue model, or new revenue models can only be possible by changing the new value proposition"* and by the other student as "*"how new value proposition(s) can attract more customers"*. This also leads to the importance of consistency issue (e.g., [58], [59], [60]). This was mentioned by a student: *"It does not cover how the company has evolved in terms of different customer segments and it does not show the development."* Business model consistency is a state of internal alignment, where all elements of a business model are in agreement with each other [61]. However, business model consistency has been called "the most powerful and neglected aspect of business models" [59], p. 104.

4) Lack of framework change: The business model framework change is another key criterion for dynamics. Models are simplifications that hold in specific conditions or when specific assumptions are met. Changes in the model can refer to aspects or interrelationships in the model. The framework needs to highlight different aspects or relationships when the assumptions no longer hold [19]. One student pointed that: *"the framework is not flexible enough for adding new blocks or relationships"*.

A student pointed out that "*the current framework does not give the complete picture as it does not visualize strategic changes over time."* Khodaei and Ortt, [19] proposed that the highest level of dynamics may require changes in the framework itself. This is in line with the definition of business model innovation as "the discovery of a fundamentally different business model in an existing business" [62], p.20.

Business model innovation "can range from incremental changes in individual components of business models, extension of the existing business model, introduction of parallel business models, right through to disruption of the business model, which may potentially entail replacing the existing model with a fundamentally different one." [63], p.324. Foss and Saebi [18] discussed that business model innovation can be discussed in terms of "scope" (as measured in terms of the amount of architectural and modular change) and "novelty" (new to the firm and new to the industry). They distinguish four types of business model innovation; evolutionary business model innovation, adaptive business model innovation, focused business model innovation and complex business model innovation. Evolutionary business model innovation is a fine-tuning process involving voluntary and emergent changes in individual components of the business model, often occurring naturally over time. Adaptive business model innovation involves changes in the overall business models that are new to the firm but not necessarily new to the industry [45]. Focused business model innovation and complex business model innovation can be defined as the processes by which management actively engages in modular or architectural changes in the business model innovation to disrupt market conditions (i.e., new to the industry). In the case of focused business model innovation, the firm innovates within one area of the business model, such as targeting a new market segment that has been ignored by its competition. In contrast, complex business model innovation affects the business models in its entirety.

B. Business model dynamics framework assessment

Next we introduced and evaluated the proposed Business Model Dynamic Framework by Kamp et al [20] by asking students to apply the Dynamic Business Model Framework and evaluate the framework based on the dynamic criteria as well as the pedagogical objectives of the course modules on business model innovation.

We asked students to evaluate the proposed Dynamic Business Model Framework based on the business model criteria of completeness, interrelationship, interrelationship overtime and framework changes through likert scale as well as open questions. Dynamic aspects are particularly well evaluated for the proposed Business Model Dynamic Framework by the students on all the items, with the interrelationship criteria receiving the highest scores. As one student claimed: "*The business model dynamics include all the essential components of a business model meeting the completeness criteria. It captures the connections between different blocks in the business model and also the interactions over time. It is also possible to accommodate changes or new findings in the business model*". Another student pointed that *" business model dynamic framework makes sure that all relevant aspects of business model are considered while focusing on keeping consistency within different elements of business model"*.

We also asked students to evaluate the Dynamic Business Model Framework in a Miro board in term of pedagogies, to help them to better understand and apply business modelling of a company. The highest mean corresponds to the second item of learning objectives with "help me better in illustrating and communicating the business model dynamics of the company".

The student pointed that: *The Business Model Dynamics Framework in Miro provides a comprehensive and holistic approach to understand and visualizing various elements of a business model dynamics. It facilitates the identification and representation of interrelationships among different components of the business model that allows for a better understanding of how changes in one element can impact others.*

And the other student mentioned: *The Business Model Dynamics Framework, used in Miro, helps analyze and visualize the changes and evolution of a business model over time. The framework highlights the interdependencies*

between different elements of the business model and helps identify and analyze feedback loops, ensuring coherent and aligned changes across the model.

Finally, we assess the framework in a Miro-board based on usability and design of the new tool and students show satisfaction with the application and a large majority of them appreciate the structure and design . Interestingly they did not rank high the user-friendliness items. On this particular aspect, the interaction between team members and team works could be improved.

V. CONCLUSION AND DISCUSSION

There is a broad consensus in the scholarly literature that entrepreneurial education may increase the desire and ability of individuals to grow and adapt knowledge and skills in order to cope more readily with non-routine tasks and continuous change e.g., [64] and [27]. Business models is one of the emerging perspectives in entrepreneurship education and it is particularly useful for introducing entrepreneurship education to non-business students [6]. However, teaching business models for startups in entrepreneurship education, requires understanding of the continuous changes in business to cope with dynamic and turbulent environment and change and adapt their business model accordingly. In line with previous studies on entrepreneurship education for engineering students, and in particular teaching business modelling, the studies emphasize on the importance and usefulness of current business model frameworks [4], here often the Business Model Canvas (BMC). In a similar line, the present study contributes to the literature on critically assessing the BMC and the challenges when applying it in dynamics situations such as the early development of a startup. The results show that the static nature of the BMC cannot capture any dynamics in the company [9]-[15].

Next, students evaluated the proposed Dynamic Business Model Framework by Kamp et al [20] based on the business model dynamic framework criteria [19], as well as the pedagogical objectives of the course modules on business modelling for startups. We encouraged students to use and apply the proposed Dynamic Business Model Framework to foster the engagement of students in "learning by doing and reflection" [65], p. 852. The results show that, from a pedagogical standpoint, the proposed framework help students to understand, apply and illustrate the business model innovation of companies and business model changes in course of time. The capacity to conduct such an analysis using this dynamic framework grants them an enhanced comprehension of the crucial factors to consider when seeking a deeper understanding of business model dynamics and the interconnected influences of these aspects. The two phases of critical assessing of BMC and proposed framework are linked into a mutually reinforcing relationship that enables student learning of business models applicable to the technology based start-ups. Indeed, questioning the effectiveness of a new method for introducing entrepreneurship is directly related "what" we teach (the business model) "how" we teach as the new approaches in entrepreneurship education (proposed Dynamic Business Model Framework) and "for what" we teach (learning objectives) (e.g., Greene and Rice's [21] and Fayolle's [22]).

VI. IMPLICATIONS FOR ENTREPRENEURSHIP EDUCATION

Our findings have practical implications for entrepreneurship education related to teaching business model particularly for engineering students. We argue that the students should be able to critically assess the currents business model frameworks and understand the dynamic nature of business model, in particular in the context of high-tech start-ups. We propose that business model dynamics frameworks are useful for learning and teaching the business model concept from a pedagogical standpoint. The students' survey shows that it helps them remember, understand and apply a conceptual model of business model dynamic. According to Bloom's taxonomy (revised by Krathwohl, [66]), the scores concerning how the application is understood and can be applied are consistent with our expectations. Our results thus, match Leschke's [6] conclusions in that the business model is useful for introducing entrepreneurship to non-business students. Our findings are particularly useful in the emerging context of technology entrepreneurship [67], a particularly under-studied context for technology entrepreneurship education [68]. We contribute to the existing stream of research on understanding of the importance of context by suggesting different conditions for different educational approaches such as business model frameworks and studying education in technology-intensive setting (e.g., [4]).

VII. FUTURE RESEARCH

Future research could compare the effectiveness of various Business model frameworks in the different setting of classroom to generate diverse and high-quality new Business model framework. It could be interesting to explore effectiveness of using different tools such as illustrative examples, case studies, and business model frameworks sequentially or simultaneously, with bigger or smaller groups of students. The Dynamic Business Model Framework, presented in this paper, is a first step to learn how to teach business model dynamic.

Hence, it constitutes a valuable contribution to the scientific domain, equipping educators and students with a valuable instrument for gaining deeper insights into the dynamic processes, origins, and various forms of alterations in business models. It facilitates the comparison of cases and enhances comprehension of the latitude entrepreneurs and managers possess in modifying their business models. The framework serves multiple purposes, aiding students in the consistent examination and analysis of data related to the origins and types of changes in business models. It visually represents these changes, fostering more efficient knowledge transfer. This graphical representation accelerates students' comprehension of business model dynamics compared to traditional textual descriptions. Furthermore, the framework introduced in this paper is adaptable, allowing for elaboration by distinguishing additional elements within a business model or incorporating various external factors.

Another interesting avenue for further research to develop deeper knowledge of business model dynamics regarding to the key role of business model consistency. In this study, we focus on engineering students. However future

research can extend the study at different context to analyze the business model education in non-engineer students to apply business model approaches to reach to more generalizability.

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