Introducing Alternative Value Proposition Canvases for Collaborative and Blended Design Thinking Activities in Science and Engineering Education

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***Abstract*—The value proposition canvas introduced in 2015 by Pigneur et al. is broadly used by entrepreneurs and intrapreneurs to create new services and products. We decided to apply it for collaborative and blended design thinking activities in a specialization in human-Computer interaction for master students in computer and data sciences. While being very useful, the original value proposition canvas relies on a business-oriented vocabulary not familiar to science and engineering students. Moreover, its underlying profit-oriented objective makes it difficult to focus on impact and trust-oriented design activities. In this paper, we propose two alternative value proposition canvases, one dedicated to sustainability for development and one to explainability for artificial intelligence. The motivations why and the ways how these alternative canvases were elicited and used in higher education are also discussed.**

Keywords—Science and Engineering Education, Computer Sciences, Data Sciences, Human Computer Interaction, Social Media, Design Thinking, Collaborative Learning, Blended Learning, Value Proposition Canvas, Sustainability, Sustainable Development Goals, Explainable Artificial Intelligence

I. Introduction

Educating science and engineering students to become responsible citizens and professionals is a challenging task. Our institution, like most universities, is addressing these challenges by integrating progressively the sustainable development goals (SDGs) and transparent data management aspirations in its curricula.

This is the case of an elective *Social Media Design* course we are proposing as part of a graduate specialization on Human Computer Interaction (HCI). Half of the course is dedicated to design thinking activities. In this framework, we ask students to design collaboratively user-centered impact or trust-oriented digital solutions tackling respectively the sustainable development goals or transparent data management aspirations.

The design thinking activities are implemented to let the students acquire good design methodologies and express their creativity [1]. These design thinking activities are carried out collaboratively to build on the various competences of the students and to train them in productive communication and negotiation. A blended learning approach is also used to benefit from the added value of digital tools and bring agility in the design process and implementation scheme, by combining synchronous and asynchronous interventions.

This paper contributes to the literature in higher education by providing a reinterpretation of the value proposition canvas proposed by Pigneur et al. [2]. We argue that this reinterpretation is very useful for supporting design thinking activities in responsible science and engineering education. The new resulting canvases can be exploited to educate the next generation of scientists and engineers to address the challenges of our society. They can be considered as boundary objects to support effectively the design process and the collaboration among students. According to [3] "boundary objects are objects that serve to coordinate different perspectives, but do not necessarily create a bridge between divergent viewpoints".

To begin, this paper highlights in Section II the key features of design thinking and the original value proposition canvas. It then presents how the original value proposition canvas was adapted to better support the creation of innovative impact and trust-oriented digital solutions. The resulting Sustainability Value Proposition Canvas (sVPC) and the Explainability Value Proposition Canvas (xVPC) are detailed in Section III and IV, respectively. The implementation of the proposed framework in a collaborative and blended *Social Media Design* course, including its objectives and scenario, the digital support tools, and the main activities are then presented in Section V. Finally, conclusions and perspectives are shared in Section VI.

II. Underlying Conceptual Framework

A. Design Thinking

The Stanford Design School model of design thinking (Fig. 1) follows five successive stages [4], namely *Empathize* to consider and understand the problem to solve, *Define* to formalize this problem as something that can be tackled, *Ideate* to elicit preliminary solutions, *Prototype* to identify and refine the best and feasible alternatives, and *Test* to validate the final solution. These stages can be revisited iteratively during the design process until the problem is perfectly defined and a final solution is reached.

In addition of being a design methodology for tangible objects or digital services in commercial enterprises and organizations, design thinking can also be considered as a pedagogical scenario when introduced to implement project-based learning activities in a design course. More precisely, students can propose an innovative solution to a problem, either individually or collaboratively, during a short activity (one class) or a long one (several classes during the semester). Using design thinking help students develop transversal skills, such as creativity (the core of

design thinking) [1], critical thinking (by selecting relevant design alternatives) [5], collaboration (when implemented in a teamwork scenario) [6], and digital skills (when the outcome is a digital tool or when digital tools are used in the design process).

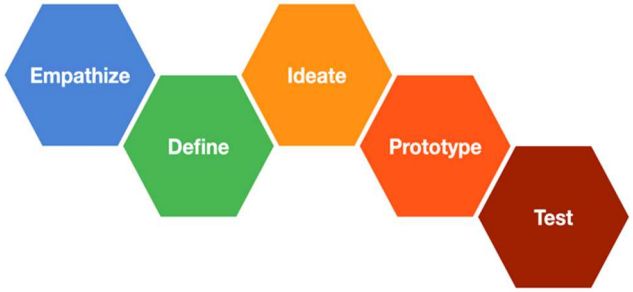

Fig. 1. Typical design thinking stages.

The value proposition canvas can be used in the *Empathize*, *Define* and *Ideate* stages of *Design Thinking* because its introduction of a boundary object is a key enabler in developing and maintaining coherence across overlapping stages [7], as well as in anchoring collaboration, as detailed in Section II-B.

B. *Value Proposition Canvas*

A canvas is typically a one-page grid or graphical representation that highlights key concepts related to a topic, a model, or a process. Canvases are frequently used in business and technology [8] to support creation, reflection, or communication.

The original Value Proposition Canvas (VPC) has been introduced by Pigneur et al. [2] to ease the elicitation of products and services. This canvas is presented in Fig. 2. In this section we will briefly explain all the elements of the canvas, in order to understand how it was adapted to other contexts.

The right-side part (circle) of the canvas is representing the **customer profile**, which highlights customer expectations in terms of job(s) to be done. Customer expectations are a set of ideas about a hypothetical or real product or service that a customer holds in his or her mind.

The left-side part (square) is representing the **value map**, which highlights provider propositions based on products and/or services (solutions). A value proposition should clearly communicate the benefits that customers can expect from using the products and/or services.

The two parts are representing the overall value proposition for a specific market segment.

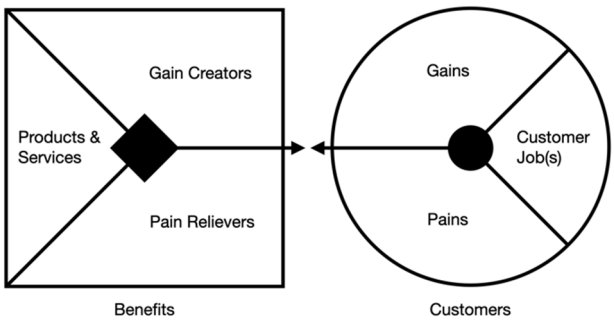

Fig. 2. Original value proposition canvas (adapted from [2]).

The same products or services can have a different value for different customers, e.g., the *Airbnb* company provides a different service to someone having a place to offer than to someone looking for a place to stay.

Like *Design Thinking* which always starts from the user's problem, the value proposition canvas always addresses the customer profile first. In that sense, the two approaches are centered on the users.

The three areas of the **customer profile** (circle) represent the customer job(s), the pains, and the gains. The concept of customer job(s) is challenging to understand for non-business people. Customer jobs describe the things customers are trying to get done in their work or in their life. Customer jobs could be the tasks they are trying to perform and complete, the problems they are trying to solve, or the needs they are trying to satisfy. The pains represent anything that causes difficulties for the customer either before, during or after a job. The gains represent various outcomes and benefits wanted by the customer. These can either be known to the customer or come as a surprise. Finally, jobs, pains, and gains can be ranked respectively from important to insignificant, from extreme to moderate, and from essential to nice-to-have, as a way to prioritize features when designing the products and/or services.

Regarding the customer jobs, Pigneur et al. [2] differentiate three categories: *Functional jobs* when a user tries to complete a specific task or solve a specific problem, *Social jobs* when a user main job is related to the perception others have of him or her, and *Personal/emotional jobs* when a user main job is related to a specific emotional state.

The three areas of the **value map** (square) represent products and services, pain relievers, and gains creators.

- Products and services are the concrete products and services that are offered. These can be tangible, intangible, digital or financial solutions.
- Pain relievers are features related to products or services that reduce customer pains.
- Gain creators are features related to products and services that create customer gains. These three elements can also be ranked from essential to nice-to-have.

A good value proposition is obtained when 1) products and services are addressing important customers jobs, 2) pain relievers are addressing extreme customer pains, and 3) gain creators are addressing essential customer gains.

In order to educate our students to become responsible scientists and engineers, we propose a reinterpretation of the value proposition canvas suitable for tackling the SDGs and transparent data management aspirations. The reinterpretation (see Section III and Section IV) is focusing on adapting the original keywords of the value proposition canvas to align them with our overall design objectives. The keywords considered are customer segment, customers, customer jobs, pains, gains, benefits, products and services, pain relievers, and gain creators.

III. Sustainability Value Proposition Canvas

In this section, we propose an alternative VPC to design impact-oriented solutions. We named it the *Sustainability Value Proposition Canvas* (sVPC).

To adapt the original value proposition canvas to designing impact-oriented solutions, we formed a participatory design group of experts, each from four different backgrounds, namely entrepreneurship,

engineering education, human-computer interaction, and humanitarian action. The group elicited a first version of the sVPC, which was validated during a winter school on water sanitation held in West Africa, where students had to collaboratively design a financially sustainable water sanitation solution integrating digital services. The final version of the canvas is presented in Fig. 3.

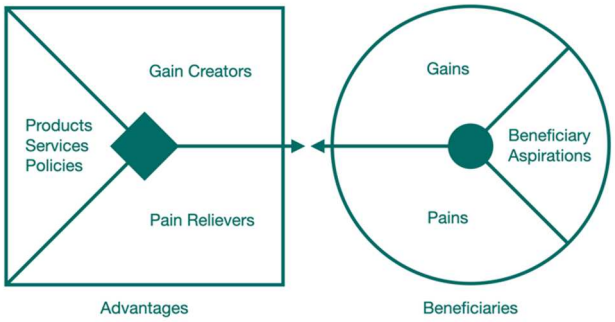

Fig. 3. Sustainability value proposition canvas (sVPC).

The changes in the vocabulary compared to the original canvas are highlighted in italic in Table I, which can be considered as a conceptual translation dictionary.

TABLE I. SUSTAINABILITY VPC DICTIONARY

Original VPC	Sustainability VPC
Customer segments	*Beneficiary segment*
Customers	*Beneficiaries*
Customer jobs	*Beneficiary aspirations*
Pains	Pains
Gains	Gains
Benefits	*Advantages*
Products and services	Products, services, *and policies*
Pain relievers	Pain relievers
Gain providers	Gain providers

Using the term "beneficiaries" instead of "customers" highlights the fact that the impact-oriented solutions are aiming at helping people, not at making profit out of them. "User expectations" become "aspirations" for themselves, their relatives or their community. Finally, achieving the SDGs, not only relies on products and services, but also on policies put in place by national or international organizations, non-profit institutions or philanthropic foundations, as well as public bodies.

IV. EXPLAINABILITY VALUE PROPOSITION CANVAS

Researchers and experts in data science and in artificial intelligence (AI) are used to deal with big data sets, complex algorithms, and data visualization. With the current trends towards the explanation of machine learning outputs to end users, human-computer interaction (HCI) concepts and user-centered approaches have to be introduced in AI and data science. The value proposition canvas is a simple but effective way to achieve this goal. It should however be adapted to the explainable artificial intelligence (xAI) context.

In this section, we propose an alternative VPC to design trust-oriented solutions. We named it the *Explainability Value Proposition Canvas* (xVPC).

Like for the sVPC, we organized participatory design sessions with AI and HCI experts to tailor the VPC to explainability. These sessions were held in the framework of a workshop bringing together the partners of an European research project on *Graph Neural Networks for Explainable Artificial Intelligence* (www.chistera.eu/projects/graphnex). Participants were PhD candidates, researchers in AI and HCI, as well as experts in xAI application domains (privacy protection and system genetics).

The participatory design sessions followed a scheme resembling a Delphi study, with a first iteration of eliciting alternative VPC keywords individually or in small teams, followed by a second iteration to refine them in a plenary session.

The first iteration started with the presentation of the original value proposition canvas, the sVPC, as well as the motivation of its introduction to devise explanation interfaces for end-users. The 20 participants were given about 30 minutes to propose alternative keywords to the original ones by working alone or with the people sitting next to them (we ended up with teams of one, two or three people). These keywords were then presented to the whole group by a spokesperson representing his or her team. During this process, keywords not really related to the original ones were discarded with the approval of the relevant team members. The outcome of this first iteration is given in Table II.

TABLE II. PRELIMINARY EXPLAINABILITY VPC DICTIONARY

Original VPC	**Explainability VPC** Initial iteration
Customer segments and customers	End users, policy makers, machine learning scientists, scientists, targeted professional or users, targeted knowledge levels
Customer jobs	Trust and discovery, expected control, higher understanding, allocated tasks, knowledge and discovery objectives, knowledge gains
Pains	Limitations, pains, doubts, black box effect, barriers to understanding, misclassifications and anomalies, mistrust, insecurity, frustrations, confusions, uncertainties, incompatibilities, misinterpretation, threat, misuse of methods
Gains	Understanding, gains, accuracy and performances, visualization, non-technical explanations, insight, compliance
Benefits	Informed decision making, explanations, predictability and interpretability, trust and acceptance, transparency, knowledge, reliability
Products and services	Method development, graphical user interfaces, visualizations, model framework, pipelines, apps, tools, knowledge, informed decision making, tools and explanations, white box tools
Pain relievers	See pains
Gain providers	See gains

Once Table II was completed and after a coffee break used for further informal discussions, we started the second plenary iteration (also for about 30 minutes). People were asked to vote for each alternative of the original keywords. Results of the vote were discussed until reaching a consensual outcome. In some cases, the discussion triggered the proposition of a new alternative. The outcome of this second and final iteration is given in Table III and was integrated in the final xVPC (Fig. 4). All the keywords are highlighted in italic, because they were all changed.

"Methods" replace "products" (from the original VPC), to underline that explanations are not only relying on user interfaces, but often require changes in the underlying machine learning approaches implemented.

TABLE III. EXPLAINABILITY VPC DICTIONARY

Original VPC	Sustainability VPC
Customer segments	*End-user segments*
Customers	*End-users*
Customer jobs	*End-user expectations*
Pains	*Uncertainties*
Gains	*Insights*
Benefits	*Actionable knowledge*
Products and services	*Methods and interfaces*
Pain relievers	*Uncertainty reducers*
Gain providers	*Insight creators*

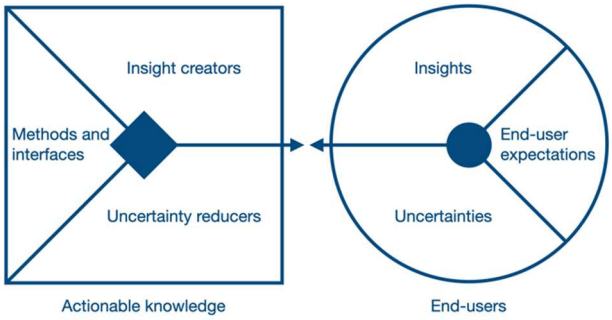

Fig. 4. Explainability value proposition canvas (xVPC).

V. IMPLEMENTATION

A. Course Objectives and Scenario

As mentioned in the introduction, having value proposition canvases customized to design thinking activities in science and engineering education contributes to promoting user-centered design. We decided to adopt them in a *Social Media Design* course taught in our institution for several years.

Master students in computer and data sciences, as well as PhD students from a doctoral program in learning sciences specializing on Human Computer Interaction (HCI) can select this course [9]. The first part of the course is dedicated to lectures and the second part to teamwork. The teamwork part aims at designing a novel social media solutions, i.e. either a mobile app or a Web platform. It follows the design thinking methodology (Section II-A) and relies on the sVPC (Section III) or the xVPC (Section IV).

Each team of students has to design a user-centered digital solution in an **impact-oriented application area** related to sustainability, namely *knowledge sharing*, linked to the SDGs 10, 16, and 17; *eHealth or humanitarian technology*, linked to the SDGs 3, 2, and 6; *ICT for development or sustainability*, linked to the SDGs 8, 11, and 12; as well as *educational technology*, linked to the SDGs 4, 5, and 9. Alternatively, they can design a solution in a **trust-oriented application area** associated to transparent data management aspirations, namely *Explainable artificial intelligence*.

B. Digital Support Tools

As a general blended learning strategy, digital tools are designed and integrated to enrich pedagogical scenarios, and pedagogical scenarios are designed and implemented to benefit from digital tools. Overall, the scenarios and the tools should contribute directly to achieving the intermediary and final learning objectives and leading to the associated learning outcome.

Following this strategy, the tools proposed to our *Social Media Design* students include an open learning experience platform, namely *Graasp* (graasp.org), built on a complete techno-pedagogical model [10], and an integrated sticky notes app.

Graasp aims at supporting the collaboration by enabling to 1) keep the created digital artifacts and the ongoing discussions at a single online place; 2) use interactive apps which facilitate the design process; 3) give on-the-fly intermediary and final presentations of the project to teammates, teaching assistants, and teachers; and finally to 4) compile the final report collaboratively. All these actions are performed in the same platform, which ensures by design the continuity of interaction. It also permits synchronous and asynchronous teamwork, either on campus or elsewhere. In that sense, it enables blended learning as we define it.

The sticky notes app can be used at various design thinking stages. First, it can be used as a sticky notes wall by teammates to elicit the problem to be tackled (*Empathize* stage of design thinking). Second, after adding one of the canvases as background, it can be employed to define the value proposition (*Define* stage for the beneficiary or end-user profile and *Ideate* stage for the value map). It is also used to discuss the evolution of the solution at the mid-term presentation of the teamwork and for the final project report (see Section V-C).

C. Main Design Thinking Activities

The teamwork activities in the *Social Media Design* course are listed and detailed below (see Fig. 5), together with their prerequisites and outcomes. They are spanning over seven weeks (half a semester) and each face-to-face (f2f) session lasts for two hours. The orchestration of these activities has been adjusted over three years until reaching an effective scenario easy to scale depending on the size of the class.

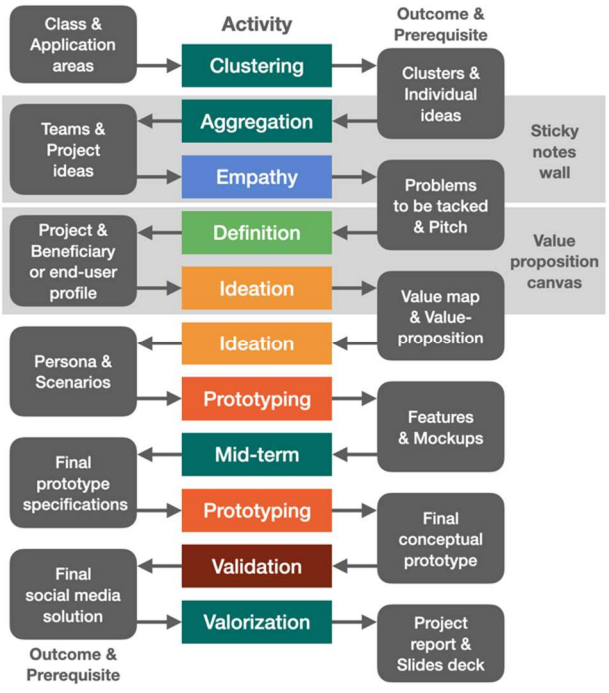

Fig. 5. Teamwork activity flow.

1) Teamwork kick-off (clustering, aggregation, and empathize activity, f2f session, first week of teamwork).

- Summary of the design thinking methodology and presentation of the application areas (see Section V-A) by the teachers.

- Clustering of the students having chosen the same **impact or trust-oriented application area** under the supervision of a dedicated teaching assistant.
- Individual proposal of a project idea answering beneficiary aspirations or end-user expectations related to one of the **application area**.
- Individual pitch of each project idea and discussion between the students from the same cluster, followed by an anonymous vote on the most interesting and innovative project ideas (See Fig. 6 for the eHealth cluster).
- Aggregation of the students in teams of four or five members around the most popular project ideas (by adding their names on the sticky note of their preferred idea). **Note**: The self-creation of teams around a common interest is a guaranty of intrinsic motivation for the rest of the project. The role of the Teaching assistants (TAs) is therefore limited to balancing the number of students in each team.
- The members of the newly formed teams get to know each other and refine their project idea for about 20 minutes, i.e., they discuss general **problems** to be tackled (*empathize*) and prepare an elevator pitch. **Note**: The short duration of this activity guarantees that the students stay in a brainstorming mode, thus avoiding too much (self-)censorship of innovative or disruptive ideas.
- Each team pitches its project idea to the TA and the other students from the same cluster to get feedback.

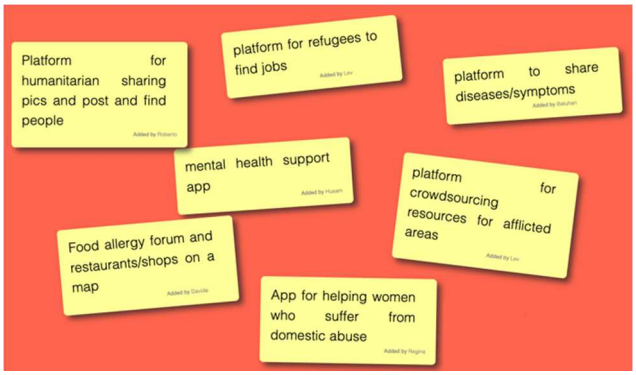

Fig. 6. Ideas proposed by students for the eHealth application area.

2) Consolidation of the problem to be tackled (definition activity, first week).

- Before the next session, each team meets f2f or virtually to respond to the feedback received and consolidate the problem to be tackled as its **project**. **Note**: This is an important activity for engineers that have the tendency to start from the solution they would like to design, rather than from the problem they would need to solve.
- Each team submit a half-a-page summary of the project (*definition*) including the **beneficiary or end-user profile**, the final team composition, as well as the selected team leader (usually the person having proposed the initial project).

3) Ideation and prototyping activities (second and third weeks). These sessions can be held on campus (with the possibility to have the support of the TAs) or off campus.

- The *ideation* activity is carried out using the value proposition canvas integrated in the sticky notes app. See the example of work-in-progress version of the sVPC as filled by one team in Fig. 7. Each team proposes a **value map** corresponding to its proposed **solutions**, as well as **persona and user scenarios** to ground and illustrate their value proposition.
- The *prototyping* activity is dedicated to devising the social and interaction **features** of the social media app or platform proposed by each team, as well as creating preliminary user-interface **mockups** of alternative solutions. **Note**: No tools are imposed to sketch the mockups. It is typically done by using real or virtual sticky notes or with a slide-based presentation software. The students are however asked to integrate these mockups in the learning experience platform.

4) Intermediary presentation (self-reflection and feedback, fourth week). This session is held on campus and students gather per cluster to present their ongoing work to the other students and their dedicated TA.

- Each team has to present its value proposition canvas, showing how its value map is aligned with the beneficiary or end-user profile.
- Teams also have to highlight possible alternative solutions and present user-interface mockups to get feedback from the audience to focus further on a single relevant prototype with its **final specifications.**

5) Final prototyping and testing activities (fifth and sixth weeks). These sessions can be held on campus (with the possibility to have support of the TA) or off campus.

- Following the feedback from the intermediary presentation, each team concentrate on a **final prototype** and revise all the design dimensions accordingly, including the pitch, the user scenarios, the value proposition and the corresponding pricing strategy. **Note**: Pricing strategy for impact-oriented and trust-oriented solutions have been discussed during the lectures prior to teamwork.
- A strategy to evaluate the final prototype of their **social media solution** with peers, friends, and family is designed and implemented (testing). **Note**: The course being worth only two European Credit Transfer and Accumulation System (ECTS), which represents a total of 56 working hours, no actual implementation of the social media app or platform is done, the general outcome stays at a conceptual level.

6) Reporting activity (sixth week).

- Before the final session, as homework, each team meet f2f or virtually to finalize the **project report** from its running draft. **Notes**: The elements to tackle in the ten-page report are: 1) Title and team description; 2) Elevator pitch as a project summary; 3) Market study (mainly investigation of and differentiation with potential competitors); 4) Persona and user scenarios; 5) Social dimensions and interaction features (Motivations); 6) Value proposition and pricing; 7) User-interface mockups; 8) Evaluation (design and results); 9) Conclusion

and self-reflection; 10) Annexes including additional mockups not part of the core sections. **Note**: The report structure is close to the one young entrepreneurs should submit when they seek for startup funding or investors.

7) Final presentation (seventh week, last week of the semester). This is a f2f plenary session with the TAs, the teachers, and invited experts.

- One or maximum two spokespersons per team present their project for a maximum of nine minutes. The **slide deck** or the silent supporting video are played automatically to have a strict control of the timing. No live Q&A is organized, but questions and comments can be posted in a chat.
- A vote is organized at the end to recognize the best presentation. Each student has two votes to cast only for projects of others. **Note**: There is no formal criteria imposed for the vote in order to expose students to the eventual biased and emotional decision process they could encounter in real entrepreneurial life. The winner is however typically the project showing a strong novelty dimension, well communicated ideas, and great graphical design (both for the slides or the video and the mockups).

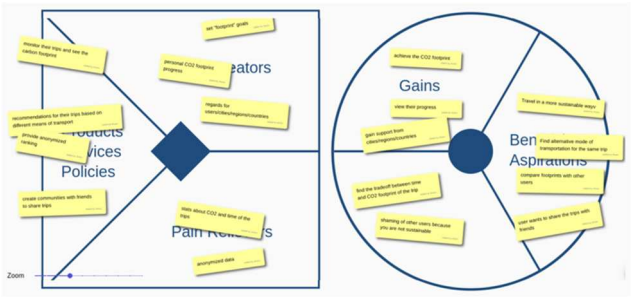

Fig. 7. Work-in-progress version of the sVPC as filled by one team.

VI. Concluding Remarks

In the context of educating science and engineering students as responsible citizens and professionals, this paper presents two value proposition canvases designed to support user-centered design thinking activities.

The two proposed canvases aim at supporting the design of impact or trust-oriented solutions, aligned respectively with the sustainable development goals and the transparent data management aspirations of the population.

The implementation of the design thinking methodology and the elicited value proposition canvases in a graduate course on *Social Media Design* is presented. The implementation scenario combines collaborative and blended activities. The objectives, the digital tools and the core activities are detailed as good practices to encourage colleagues to further strengthen active learning opportunities in science and engineering education, in adequacy with the technical, societal, and environmental issues that the living species, the nature, and the planet are facing.

The design of the canvases and the course implementation scheme proposed in this paper can be reused and mapped in other courses. The pedagogical validation of the course itself is work in progress, taking into account the challenges to assess the acquisition of a design methodology and transversal skills. Such skills can hardly be assessed like core competences through short-term control experiments with timely pre-tests, alternative interventions, and post-tests. More long-term impact analyses have to be carried out. Outside influences on students following different personal and academic paths should also be considered. Fortunately, the use of digital tools enable quantitative engagement analyses through learning analytics, which can give an idea of the educational impact of the proposed approach. One should however keep in mind that digital traces only capture part of the blended activities and little of the learning outcome.

Finally, it is worth mentioning that the two alternative value proposition canvases proposed in this paper can be used beyond education, especially in business and research, to support sustainable development and explainable AI.

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