Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 232 (2024) 2767–2776

Procedia Computer Science

www.elsevier.com/locate/procedia

5th International Conference on Industry 4.0 and Smart Manufacturing

Applying strategic analysis for designing an educational program in smart manufacturing: the case of MIMS

Andrea Bikfalvi[a,*], Martí Casadesus[a], Rodolfo de Castro[a], Inés Ferrer[a], Lea Fobbe[b], Maria Luisa Garcia-Romeu[a], Pilar Marques[a]

[a] *University of Girona, C/ Maria Aurèlia Capmany, 61, 17003 Girona, Spain*
[b] *University of Gävle, Kungsbäcksvägen 47, SE-801 76 Gävle, Sweden*

Abstract

In this paper, we propose the application of strategic analysis tools to design an educational program. Findings are based on the case of the Master in Innovative Manufacturing Systems (MIMS), a unique training offer to achieve a multidisciplinary expertise in smart manufacturing, in a two-year program simulating the journey of innovation. Building on novel educational paradigms and recent developments in the area of manufacturing, the main goal of the program is to provide the European industry with outstanding experts willing, able, and trained to bring novel solutions that address relevant societal challenges. Special emphasis is placed on real-world contexts and proactive activities, as well as strategies to continuously update the program. We aim to contribute to the educational facet of smart manufacturing.

Keywords: learning; education; training; technology; smart manufacturing.

1. Introduction

The rise of ICT solutions affecting all areas of life calls for a continuous update and transformation of education. Training and development are key to facing the future, which is uneasy to predict due to its complex nature. Education in general, and higher education in particular – due to its main role in society- can be assimilated to a talent factory. Training the professionals of the future is a present relevant issue, with special care on reducing the gap between

* Corresponding author. Tel.: +34-659-997-640; fax: +34-972-418-031.
E-mail address: andrea.bikfalvi@udg.edu

1877-0509
10.1016/j.procs.2024.02.094

graduate-acquired and *employer-required* competencies, especially relevant in the postgraduate training levels. Having a shared and holistic understanding of what the education of the future *is* or *should be*, the OECD's learning framework 2023 is showed in Figure 1.

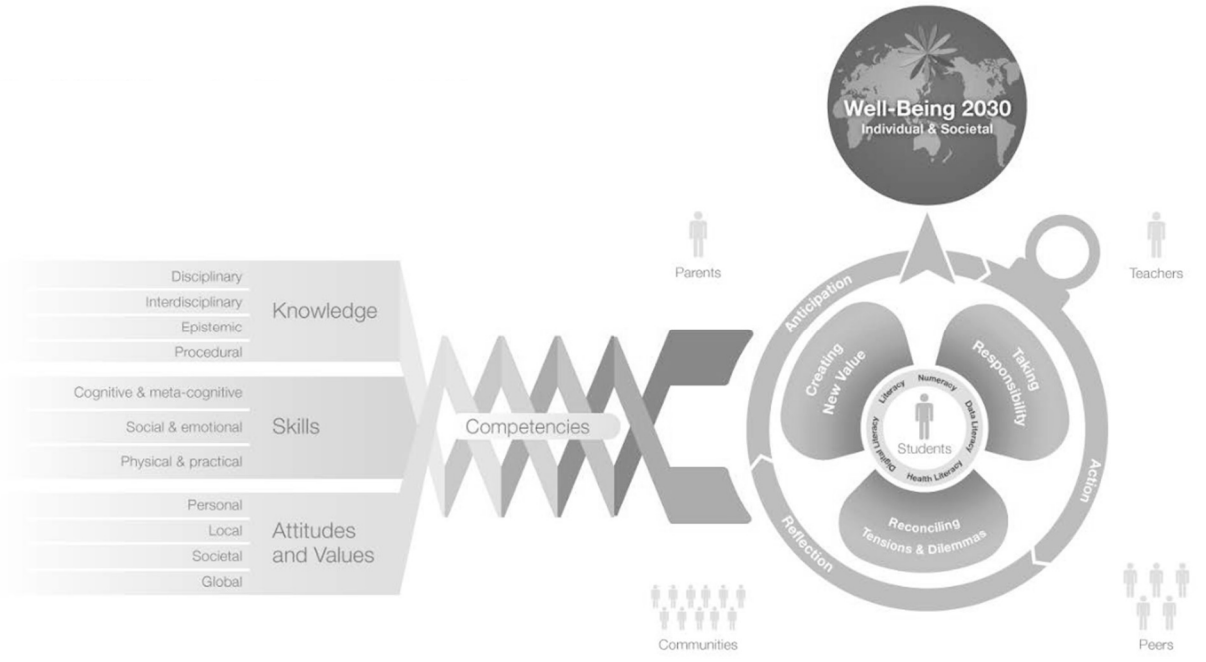

Fig. 1. The OECD Learning Framework 2030: Work-in-progress [1].

According to the European Institute of Innovation and Technology [2] added-value manufacturing is one of the nine global challenges of Europe together with climate change, cultural and creative sectors and industries, digitization, the future of food, health innovation, sustainable energy, raw materials, and urban mobility. Manufacturing is the main driver of Europe's industrial innovation, job creation, and its growth. But the manufacturing sector remains too fragmented and beholden to unsustainable economic models [3]. It is speeding up the take-up of sustainable innovations in manufacturing technology. And most important of all, it is giving power back to the people with the skills to be the workforce of tomorrow. Value-added manufacturing, based on knowledge and innovation, is a general ambition with the ultimate aim of being Europe's industry community, and societal agent of change caring for the people and the planet.

It is on these premises that we build the present paper describing the process of designing an educational program on smart manufacturing, particularly, the Master in Innovative Manufacturing Systems (MIMS), embracing novel educational approaches and trends in manufacturing. The challenge in designing a master's program on Industry 4.0 lies in aligning (rather traditional) education with the rapidly evolving and interdisciplinary nature of this transformative industrial paradigm. We use tools positioned in the field of strategic analysis, employing them to critically assess user needs (*empathy map*), competitors (*value curve*), positive and negative aspects (*SWOT*), and the resulting business model (*Canvas*). Using strategic analysis tools might become highly useful in the design of a master's program on Industry 4.0 for several reasons: aligning with industry needs and market demand, identifying trends and emerging technologies, competitor benchmarking, resources and capabilities identification and allocation, long-term viability and return on investment, alignment with institutional goals and partnership opportunities.

2. Methods

We have been involved in an in-depth case study of a master's program developed within an Erasmus Mundus framework. With the collaboration of three universities - Politecnico di Torino (Italy), Högskolan I Gävle (Sweden), and Universitat de Girona (Spain) - the program has been designed following the approach of an innovation project, that is, understanding the overall training program as an innovation project, simulating a complete innovation journey. This journey consists of four stagesuc : “Ideate & Initiate”, “Sophisticate & Prepare”, “Execute & Deliver” and “Integrate and Apply”. Figure 2 presents a visualization of the Master curriculum as an innovation process.

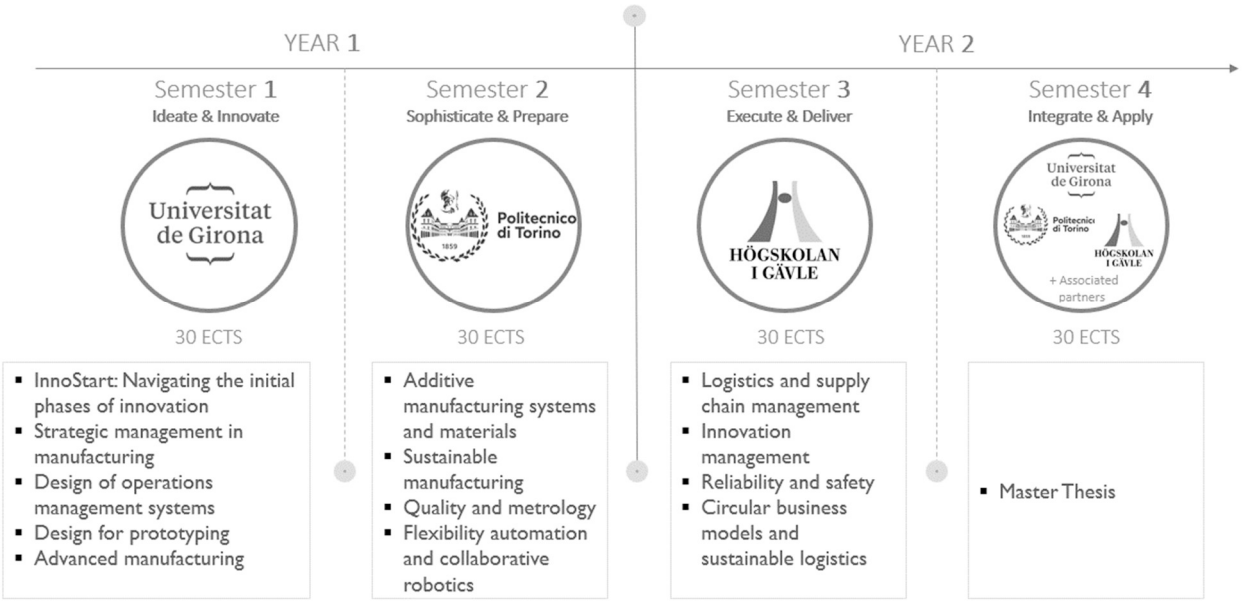

Fig. 2. The MIMS process and learning curriculum

We build MIMS on complementary resources and capabilities - access to modern and traditional classrooms, computer labs, drilling machining labs, 3D printer labs, libraries, among others - available at each university. The two-year master’s degree consists of 120 ECTS (according to the European Credit Transfer System (ECTS)) with each ECTS consisting of approximately 25 hours of workload for the student. While some courses focus purely on engineering or business aspects, most courses combine both disciplines. Students will be offered a highly international and interdisciplinary context due to the origin of participants, teachers, and contents.

The sources of information we have used in formulating MIMS are based on the previous experience gained by each partner university (similar master’s programs), with evidences captured through student satisfaction surveys, focus groups with current and prospective students, interviews with experts in the field of industry and education. The available information was processed for the purpose of the analysis, followed by a discussion on the validation of the program in terms of two aspects, accreditation and sustainability of the program.

3. Results and Discussion

3.1. The strategic analysis to design a master in smart manufacturing

3.1.1. Trends in education

Nowadays, the need to be updated in the digital world is increasingly notable. The pandemic experienced in recent years only accelerated this process, and organizations had to adapt more quickly and accelerate the digital transformation that was already ongoing [4]. Higher education, and its surrounding competitive landscape [5], has

radically changed in the last decade, especially due to the introduction of educational technology (EdTech) and novel approaches, that affected both content and methods. Table 1 highlights some of these trends.

Table 1. Trends in Education.

Trend	Brief description
	Preparing for a new future
Trend 1 - Rising demand for global problem solvers	As the world faces a new set of global challenges, education systems will become a central part of the solution, helping future generations embrace global mind-sets and skill sets.
Trend 2 - Change in the skill sets required for work	As technology advances, education will focus on equipping students with the high-demand skills they'll need to thrive in a new world of work.
Trend 3 - Shift to a lifelong learning mind-set	As lifespans increase and societal change accelerates, the idea of lifelong learning is gaining traction, with more tools available for upskilling and advancement.
	Evolving how we teach and learn
Trend 4 - Making learning personal	Advancements in artificial intelligence (AI) and adaptive technologies enable educators to meet learners where they are, with experiences tailored to their needs.
Trend 5 - Reimagining learning design	As new technologies become more accessible, educators aim to understand how they can support engaging and enriching learning experiences.
Trend 6 - Elevating the teacher	As the educational landscape changes, teachers shift from being 'gatekeepers of knowledge' to 'choreographers of learning.'

Source: [6], [7]

3.1.2. Trends in manufacturing

In recent years, the manufacturing industry has witnessed a rapid evolution driven by technological advancements and changing consumer demands. Conventionally, most industrial parts are made by either machining or moulding metals or plastics, which are generally non-flexible processes. The complexity of modern products, as well as the associated manufacturing processes, have increased over the past few decades and there is evidence that the trend will continue. Complexity means challenges for functionality and increased complexity, leading to a clear evolution in several dimensions for manufacturing (see Table 2).

Table 2. Trends in Manufacturing.

Trend	Brief description
Trend A - Novel and hybrid materials	Smart materials and composites and their corresponding new geometries (customization possibilities)
Trend B - Design: Weight reduction	Autonomous vehicles, alternative energy (efficiency), decrease of fuel consumption
Trend C - Additive Manufacturing, AM	AM processes offer significant potential in fabricating parts with multi-functionality such as through graded mechanical properties [9]
Trend D - Lean & Green manufacturing & Sustainability	Sustainable Production, Lean Supply Chain
Trend E - Virtualization & Automation	Artificial intelligence (AI), Nanotechnology, Industrial and Internet of Things (IIoT, IoT), Manufacturing optimization and Digital Twins

Source: Based on [8], [9].

Although an increase in complexity is positive, it brings a series of challenges. This means that if manufacturing, in general, and products (goods and services), in particular, become more sophisticated and more functional, it is necessary to resort to higher manufacturing quality, use better and advanced materials, with stricter tolerances, but without losing quality. Consequently, *first* there is a demand for more advanced skills, requiring significant investments in training or hiring specialized talent. *Second*, implementing and integrating complex technologies may lead to higher initial costs, with the corresponding financial implications to be considered. Nowadays, managing the vast amounts of data generated becomes intricate, requiring robust analytics systems, which results in a demand for

employees with these skills. And *third*, the interoperability of different systems (new and existing in companies) presents a challenge in achieving a seamless operation and needs to be considered. The necessity to be trained and up-to-date is becoming more and more apparent in the digital age. Professionals with HEI degrees who want to advance in their current position, increase productivity in their daily role, and contribute to business advancement can benefit from the MIMS master's training. To this aim, the MIMS curriculum is organized in four modules responding to the main trends described in Table 2. How the MIMS models cover the mentioned trends in manufacturing are presented in Table 3.

Table 3. Connecting trends in manufacturing with MIMS modules and contents.

S	Module	Trend in Man.	Examples (Related contents)
1	"Ideate & Initiate"	B, D, E	- Creating Virtual replicas of physical systems facilitate simulation and optimization, for example, digital twins of a manufacturing process for predictive analysis and process refinement. The master deals with disruptive technologies that are not yet mature in the market, but that will be part of the future. (*Design for prototyping, Advanced Manufacturing*).
2	"Sophisticate & Prepare"	A, C, D	- Moreover, AM has redefined traditional manufacturing, allows for intricate designs for example producing complex components with reduced material waste. Developing lightweight and durable materials for components. (*Additive Manufacturing systems and materials*). - AI-powered vision systems identifying defects on a production line and triggering immediate corrective action. Cobots work alongside human workers, enhancing efficiency and safety. Autonomous guided vehicles (AGVs) efficiently moving raw materials within a warehouse. (*Quality and metrology, Flexible automation and collaborative robotics*).
3	"Execute & Deliver"	D	- Transparency in reporting carbon emissions and obtaining sustainability certifications, like ISO 14001, underscores a commitment to environmental responsibility. Innovations in sustainable materials, such as bioplastics, showcase a move away from traditional, less eco-friendly options. Exploring ways to recycle and reuse components, exemplifying a holistic approach to product life cycle sustainability. (*Sustainable manufacturing*) - Supply chain management becomes more intricate, demanding synchronization across diverse components. Adding ethical practices throughout their value chain. (*Logistics and supply chain management, Reliability and safety*) - Circular economy principles are gaining prominence, with firms redesigning products for recyclability and implementing closed-loop systems. For instance, companies employ recycled materials in their production, demonstrating commitment to SDGs and circularity. (*Circular Business Models and Sustainable Logistics*).
4	"Integrate & Apply"	A, B, C, D, E	- MIMS *Master's Thesis*

Abbreviations: S – Semester; Man. – Manufacturing.

3.1.3. What students want

Empathy Maps are a very useful tool to analyze what we know about a particular type of user, a student in our case. It produces explicit knowledge about users to 1) create a shared understanding of user needs, and 2) aid in decision making. Table 4 represents the MIMS student empathy map.

Table 4. Student Empathy Map.

Key question	Explanation
Who are we empathizing with?	Bachelor graduates (young and adult) who seek to continue expanding their engineering and management studies in a key professional (manufacturing) and scientific (innovation) area.
What do they need to do?	They need to broaden and deepen their knowledge and gain more experience to be able to enter the labour market or develop professionally.
What do they do?	The consumer tends to complement their studies with innovative vision.
What do they hear?	Family, colleagues and friends who probably talk to you about the importance of doing a master's degree or had a previous experience in coursing one.

What do they see?	Variety of training offers focused on innovation, entrepreneurship, MBAs, on-line courses.
What do they say?	It is likely that the potential student is aware about the advantages of doing a master's degree, but some factors might be determinant: personal situation, economic factors, language, etc.
What do they think and feel?	*Pain*: uncertainty about the job opportunities as a consequence of coursing a master.
	Gain: complement and up-skill knowledge and be c(more) competitive in the labour market.

3.1.4. Differences between MIMS and other educational offers – MIMS value curve

MIMS can be considered an educational offer that has to compete with other masters. In this sense, to analyse its competitiveness we analyse the value curve of MIMS in comparison to four other masters that share characteristics with MIMS topic (Figure 3).

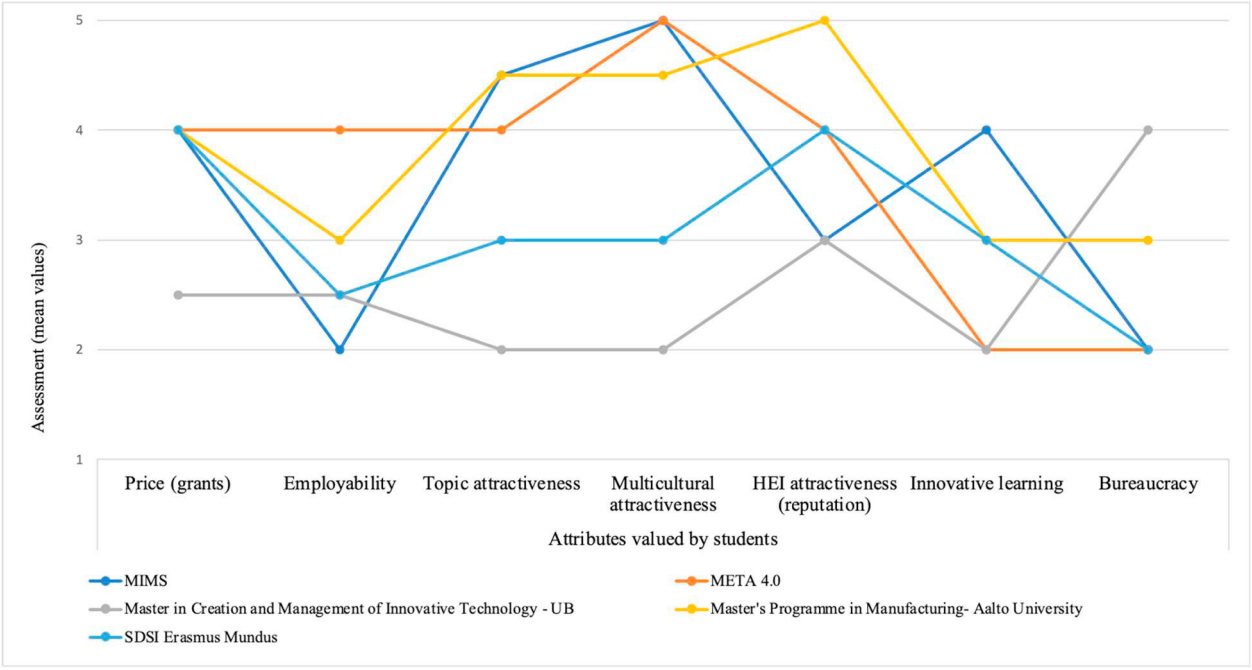

Fig. 3. MIMS value curve.

The value curve is a graphical representation of the perceived value of a product or service from a customer's point of view. This analysis visualises the competitive positioning of a product or service based on the main preferences of the customers, in this case, candidate students. These preferences are identified through demand analysis or an empathy map. In this case, the chosen elements are the following:

- Price (grants): one of the major factors involved in choosing a master's degree is its affordability. MIMS is highly valued in this aspect because of registrations being funded by Erasmus Mundus grants.
- Employability: the most important reason to study a master is to specialise further and be more employable or access better jobs. Being MIMS a master with no previous experience can be seen as uncertain as regards to how it can enable a high employability of graduates and about how it will be valued by employers.
- Topic attractiveness: students chose a master based on how appealing it is for them in their chosen topic. The MIMS attractiveness can be found in its interdisciplinary subjects allowing future graduates getting a wide range of job positions.

- Multicultural attractiveness: studying and living abroad is an enriching experience, hence situating MIMS in the best position because it allows students to get to know three different countries and their cultures. In addition, multiculturality is likely to be found also among classmates.
- HEI attractiveness: institution's reputation is also important to differentiate from other candidates when getting a job. MIMS's competitors are at the top of the best technical European Universities or Research Institutes.
- Innovative learning: improving the teaching methods is a must for the correct student development and later performance in a job position. MIMS is highly valued in this aspect due to the proactive training methods, outdoors events and the challenge-oriented group projects.
- Bureaucracy: studying an Erasmus Mundus master and studying abroad brings challenges with bureaucracy, and processes such as obtaining visas, insurance, etc., which can be triple because of a master taking place in three different countries.

3.1.5. Resources and capabilities needed

To build and sustain a competitive advantage, MIMS needs to create and maintain the adequate resources and capabilities that must be valuable for the students, rare to provide a competitive advantage and quite inimitable by other masters, as well as being resources and capabilities appropriable by the consortium to sustain such advantage.

Looking at the value curve and its relative position in the masters offer, the three elements that should be improved more are employability, bureaucracy, and HEI attractiveness. Bureaucracy depends on the country's government itself, but the universities should exploit their capability to learn about the facilities and difficulties international students face during the application process to offer a less arduous procedure for new applicants.

To improve employability a resource to be exploited could be developing some of the group projects during the semester directly with the associated businesses or universities to stablish from the beginning a future job offer-candidate relationship. On the other hand, enhancing reputation is a continuous and complex endeavour, but with effects generally beyond the short term. Reputation has also effects on employability. MIMS can itself contribute to reputation building, through reputable and innovative teaching methods, notorious professors and renowned guest speakers. Also participating in high prestigious congresses, symposiums or competitions would allow the master to be known and create an outstanding image compared to the other competitors.

3.1.6. SWOT analysis

The main internal and external, both positive and negative aspects relevant for the MIMS program are summarized in Table 5.

Table 5. SWOT.

Positive	**Negative**
Strengths	**W**eaknesses
- Attractive proposal of training and complementary activities	- No previous MIMS edition
- High quality research in the field	- Administrative burdens for students (language)
- Motivated staff	- Numerous jobs-to-be done by students before arrival (visa, insurance, accommodation, travel, etc.)
- Latest generation labs	- No previous experience of the three partners as a consortium
- Previous experience in international training	- Initial difficulty to understand local language and culture
- Expertise and relevance of consortium HEIs	- Diversity management
- Support received from numerous associated partners	
- Connection to industry and territory	
- Connection with other Erasmus Mundus master students	
Opportunities	**T**hreats
- Multidisciplinary approach to innovation	- No interest of self-funded students for MIMS
- Variety of labour insertion opportunities	- Incompletion of commitment of associated partners
	- MIMS does not meet high expectations of students

- Possibility to connect with different cultures and have a unique learning experience
- Access to (industrial) PhD
- Meet the challenges of the manufacturing sector by working on real projects
- Student demotivation and/or drop-out
- Increase in tuition fees
- Fear of travelling and moving abroad
- Natural disasters, geo-political conflicts and global health issues jeopardising planned functioning of MIMS

3.2. The solution: a master program for Smart manufacturing

A key issue in profiling MIMS is defining its value proposition, which in a summarized version is "*An international and multidisciplinary training on innovation in manufacturing based on innovative experiential learning and European mobility*". A detailed version of the business model constructed around MIMS is showed in Figure 4.

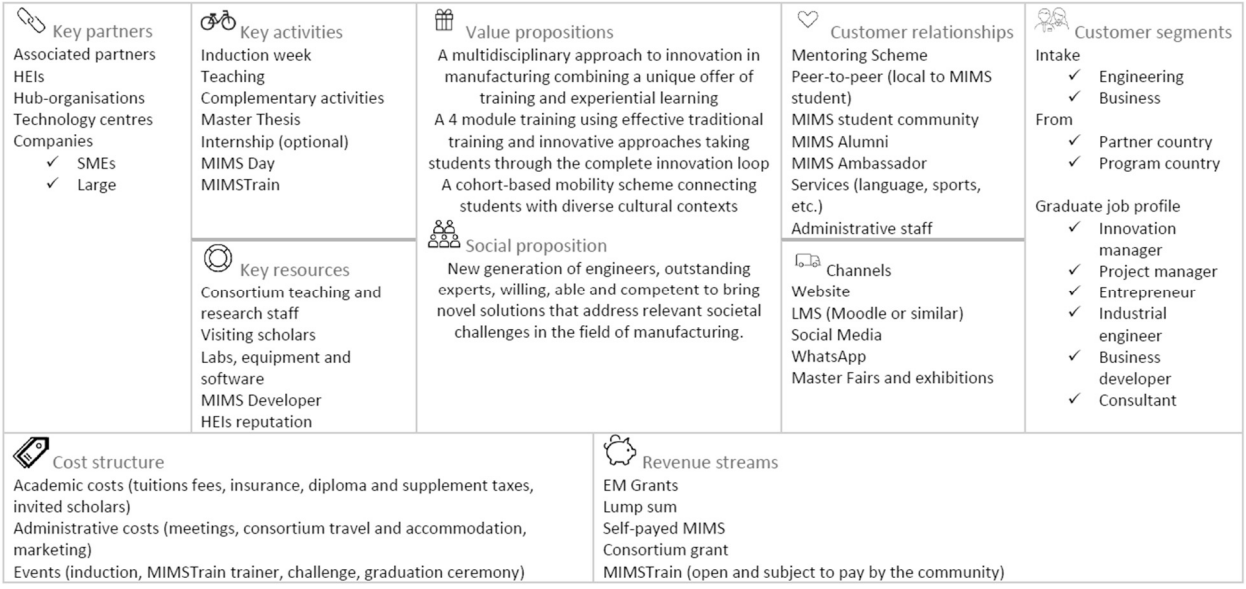

Fig. 4. CANVAS of MIMS.

3.3. The validation

3.3.1. Accreditation of MIMS

It is essential that MIMS is accredited by any external agency included in the European Quality Assurance Register for Higher Education (EQAR). The Consortium has decided to be accredited according to the European Approach European Approach for Quality Assurance of Joint Programs to simplify the assessment processes in the different countries involved.

This strategy will ensure that the program is accredited by the Spanish authorities automatically. However, unfortunately, national laws in Italy and Sweden are not yet sufficiently developed to implement the European Approach for Quality Assurance of Joint Programs immediately (see [10]) and automatically accredit the program. Some legal changes are still needed. The consortium has visited both External Quality Assurance Agencies (EQAAs) (ANVUR in Rome on February 2023 and EKA in Stockholm on May 2023), and it is confirmed that on both cases they are promoting these regulatory changes on their Governments. Nevertheless, following the European Approach standards will undoubtedly facilitate the accreditation in these countries.

To accomplish this objective, AQU Catalunya (The Catalan University Quality Assurance Agency) was the EQAA selected by the consortium for the initial (ex-ante) accreditation. As an EQAR-registered agency, AQU is a full member of the European Association for Quality Assurance in Higher Education (ENQA).

The consortium applied for the European Approach for Quality Assurance of Joint Programs accreditation to AQU Catalunya in January 2023. To be successfully accredited, the design of the program had to report and comply with the 9 dimensions included in the European Approach for Quality Assurance of Joint Programs: 1. Eligibility; 2. Learning outcomes; 3. Study program; 4. Admission and recognition; 5. Learning, Teaching and assessment; 6. Student support; 7. Resources; 8. Transparency and documentation; 9. Quality assurance. The external panel visit, with experts from the three involved countries, was organized in May 2023. In July 2023, the consortium received the preliminary report, which included 9 requirements and 28 recommendations. In September 2023, all requirements and some recommendations were addressed. We expect to obtain the final report by October 2023. As the main result of the visit, various changes have been made, including those to the admission process and student support. However, the main structure of the program (proposed courses and content) has remained intact. If accredited, the results of the accreditation will be finally published in DEQAR (Database of External Quality Assurance Results).

According to the European Approach for Quality Assurance of Joint Programs, the program should be reviewed periodically every 6 years. During this 6-year period, the consortium will inform to AQU Catalunya any changes in the joint program according to the guidelines published by the EQAA. In consequence, the first ex-post accreditation is planned for July 2029 approximately, with 3 cohorts of graduates.

UdG will be responsible for the overall administration of the external review process. To facilitate this process, the UdG's Quality Management System will be used. In the delivery of the program student satisfaction surveys and interviews with employers will be used to assure and monitor perceived quality.

3.3.2. Sustainability of MIMS

Designing and implementing a sustainable master program requires a shift towards interdisciplinary systems thinking where sustainable development is a central part in the content, context and process of learning and education [11] [12]. The MIMS program emphasizes this shift through participative approaches and close collaboration with the industry and among higher education institutions in different countries [13] [14]. For example, by actively considering the interdependency of the curriculum, research activities and campus experiences, the MIMS program may facilitate a transformative learning experience strengthening the process and quality of learning [15]. Further, by stimulating research activities with industry partners and by incorporating soft skills such as critical thinking, innovation, and international orientation in the manufacturing curriculum, the MIMS program equips students with the ability to learn and the competencies and tools for identifying and successfully solving real-world sustainability problems. This dual approach of the MIMS program focused on enhanced learning including field activities and the international environment may also be a response to the increasing complexity and uncertainty experienced in societies ensuring sustainable education [12].

This makes the MIMS program not only innovative and sustainable through its content and methods but also in line with current discussions of scholars and society highlighting how educational programs can contribute to navigating and fostering future generations towards sustainability [13] [16]. To ensure the long-term contribution of the MIMS program to sustainability, the content, e.g. how sustainability issues are addressed in various subject-matters, the context and the process of learning, e.g. number of students, industry partners and sponsors, as well as employment options for MIMS graduates are continuously assessed via curricula assessment and student and industry perceptions [17] [18]. Thus, the MIMS program may lead to a new generation of change agents who can address relevant societal challenges in the manufacturing field.

4. Conclusions

Education and smart manufacturing have evolved on their own specific tracks but in order to face future challenges there is a need for a coordinated effort and a meeting point between the two. Formulating and orchestrating the Master in Innovative Manufacturing Systems (MIMS) is one step in this direction. In the design phase of MIMS, a series of strategic management tools have been employed to assess *if* and *how* MIMS should be structured, deployed and delivered.

Our findings show the usefulness of MIMS considering a series of steps, that simulate the innovation journey. Active methodologies, in- and out-door activities, will allow the learning experience both at individual, group, and

class level. The implication of students, teachers, and wider ecosystem actors from three different geographical contexts of Europe are key for MIMS success.

One main limitation is the current design status of the master. At this stage it is not possible to foresee the precise impacts and benefits, only the expected ones. Borrowing the 5Ps from project management equivalent to "*Proper Planning Prevents Poor Performance*", we envision that a successful design is anticipated to bring an effective program, which will be specially assessed by students' satisfaction, labour insertion and professional trajectories deriving from the master. On a more global level, the main aspiration of the educational program is to contribute to a new generation of professionals, experts in smart manufacturing, but also sensitive and skilled for facing the social, economic and environmental challenges of the present and near future.

Acknowledgements

This work was supported by the European Education and Culture Executive Agency, in the call ERASMUS-EDU-2022-EJMJ-DESIGN, project number 1010182195.

References

[1] Organisation for Economic Co-operation and Development - OECD (2018) The Future of Education and Skills - Education 2030. Retrieved July 05, 2023, from https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf.

[2] European Institute of Innovation and Technology – EIT (2023) Added-Value Manufacturing. Retrieved July 03, 2023, from https://eit.europa.eu/our-communities/eit-manufacturing.

[3] European Institute of Innovation and Technology – EIT (2023) Added-Value Manufacturing webpage. Retrieved July 03, 2023, from https://www.eitmanufacturing.eu/.

[4] Rof, A., Bikfalvi, A.; Marques, P. (2022). Pandemic-accelerated Digital Transformation of a Born Digital Higher Education Institution: Towards a Customized Multimode Learning Strategy. Educational Technology & Society, 25, 124–141.

[5] Rof, A., Bikfalvi, A., Marques, P. (2022). Born-Digital Universities Facing the New Competitive Landscape. In A. Kaplan (Ed.), Digital Transformation and Disruption of Higher Education (pp. 269–288). Cambridge University Press.

[6] Google for Education (2023) Trend Forecast Report 2022 - Preparing for a new future: Future of Education. Retrieved July 04, 2023, from https://services.google.com/fh/files/misc/foe_part1.pdf.

[7] Google for Education (2023) Trend Forecast Report 2022 - Evolving how we teach and learn: Future of Education. Retrieved July 04, 2023, from https://services.google.com/fh/files/misc/foe_part2.pdf

[8] Alimi, O.A., and Meijboom, R. (2021) Current and future trends of additive manufacturing for chemistry applications: A review. Journal of Materials Science, 56(30), 16824-16850. doi:10.1007/s10853-021-06362-7

[9] Billah, K.M.M. Coronel, J.L., Chavez, L., Lin Y. et Espalin, D. (2021) Additive manufacturing of multimaterial and multifunctional-structures via ultrasonic embedding of continuous carbon fiber Composites Part C Open Access, vol. 5, 7.

[10] EQAR (2023) The European Quality Assurance Register for Higher Education. Retrieved June 19, 2023, from https://www.eqar.eu/kb/jointprograms/national-implementation/.

[11] Cortese, A. (2003). The critical role of higher education in creating a sustainable future. Planning for Higher Education, 15–22.

[12] Sterling, S. (2008). Sustainable education – Towards a deep learning response to unsustainability. Policy & Practice. A Development Education Review, 6 (Spring), 63–68.

[13] Hesselbarth, C., & Schaltegger, S. (2014). Educating change agents for sustainability - Learnings from the first sustainability management master of business administration. Journal of Cleaner Production, 62, 24–36. https://doi.org/10.1016/j.jclepro.2013.03.042

[14] Klimova, A., Rondeau, E., Andersson, K., Porras, J., Rybin, A., & Zaslavsky, A. (2016). An international Master's program in green ICT as a contribution to sustainable development. Journal of Cleaner Production, 135, 223–239. https://doi.org/10.1016/j.jclepro.2016.06.032

[15] Sterling, S. (2001). Sustainable Education: Re-visioning Learning and Change. Green Books for the Schumacher Society.

[16] Son-Turan, S. (2020). The HESFS for higher education funding, employment and sustainability. International Journal of Sustainability in Higher Education, 22(1), 100–119. https://doi.org/10.1108/IJSHE-10-2019-0310

[17 Remington-Doucette, S. M., Connell, K. Y. H., Armstrong, C. M., & Musgrove, S. L. (2013). Assessing sustainability education in a transdisciplinary undergraduate course focused on real-world problem solving: A case for disciplinary grounding. International Journal of Sustainability in Higher Education, 14(4), 404–433. https://doi.org/10.1108/IJSHE-01-2012-0001

[18] Watson, M. K., Lozano, R., Noyes, C., & Rodgers, M. (2013). Assessing curricula contribution to sustainability more holistically: Experiences from the integration of curricula assessment and students' perceptions at the Georgia Institute of Technology. Journal of Cleaner Production, 61, 106–116. https://doi.org/10.1016/j.jclepro.2013.09.010