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Expanding the Heroine's Learning Journey: Enhanced Strategies for Engaging Young Women in STEM via Heroic Narratives

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Abstract
The Fostering Women to STEM MOOCs (FOSTWOM) project aims to increase women's participation in STEM careers through free-access Massive Open Online Courses (MOOCs) targeted at young women. One of its key actions was the development of the Heroine's Learning Journey (HLJ), a framework structured into 3 acts and 12 stages, employing a heroic narrative to inspire and empower young women, ages 15 to 21, to persist in their STEM studies. This work assesses the effectiveness of the HLJ stages through complementary evaluations involving students' video ratings, students' reflective reports, and expert assessment. The first evaluation with 12 educational specialists — professors, researchers, instructional designers, media producers, and pedagogical coaches — and the second with students participating in the MOOCs. Results show that all HLJ stages received at least 60% positive ratings regarding motivational capacity, with Stages 1 and 5 rated particularly highly. However, Stages 6 and 9 needed improvements for greater clarity and engagement. Qualitative student feedback also highlighted Stage 10 (Self-Regulated Learning) as a critical moment of reflection and growth. The HLJ was recently recognized with the SBC Innovation Seal and the SIGHP Education Award. Our results offer valuable insights for educators seeking to design MOOCs that address gender-equality needs in STEM fields.

Keywords: *Women; STEM; Heroic Narratives; FOSTWOM; MOOCs; Gender Equality; Education*

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1 Introduction

Current educational methods often struggle to inspire young learners and fail to connect abstract scientific concepts with real-world relevance. Storytelling is one approach that can make classes more motivating, but students and teachers have difficulty creating stories (Oliveira & Classe, 2024). This disconnect is evident in many classrooms, where students frequently appear bored and disengaged from learning and school (National Research Council, 1996). Moreover, during crises such as the COVID-19 pandemic, educational leaders needed to cultivate a culture of transformational learning to meet growing technological and social demands. While the potential for digital technologies to revolutionize education is substantial, the impact has remained limited (OECD, 2016).

This issue is particularly pronounced in the lack of personalized learning tools and inclusive educational content that can effectively engage students from diverse backgrounds (Harvard Center for International Development, 2024). Another documented issue is that women in STEM face significant challenges rooted in societal constructions of gender roles imposed from an early age. Girls are often conditioned from childhood to believe they are better suited for caregiving roles (Musil et al., 2004), while STEM careers present them with lower expectations for success from peers, teachers, parents, and even themselves (Stein, 2019). When women enter STEM courses, they frequently encounter masculine language, implicit biases, and exclusionary practices due to their minority status. These barriers prevent their ideas from being heard or valued equally, creating additional obstacles to participation and retention (L. F. C. Costa, Nascimento, et al., 2024). Therefore, it is critical for any course aimed at women in STEM to place special emphasis on motivation, both at the initial stages of entry and throughout their educational journey. To help close the gap in the participation of young women in STEM fields and increase the number of qualified individuals by 2030 (European Commission, 2023) in these fields, it is necessary to cultivate a diverse set of cognitive, technical, and social skills essential to thriving in future STEM fields (Stein, 2019). According to Galeno et al. (2024), most research on gender diversity in collaboration mainly focused on learning, and most studies lacked defined collaboration models.

The Encouraging Women to STEM Massive Open Online Courses Project (FOSTWOM) (Corti et al., 2021) is a three-year initiative launched in early 2020 and partially funded by the European Commission's Erasmus+ program – KA2 Cooperation for Innovation and the Exchange of Good Practices – Strategic Partnerships for Higher Education. The project aims to leverage the inclusive potential of MOOCs to challenge gender stereotypes in STEM education. By creating an environment free of these stereotypes, the FOSTWOM project seeks to attract more women and increase the number of young women pursuing STEM careers. The consortium supporting the FOSTWOM project is dedicated to promoting young women's participation in STEM through the development of accessible, gender-sensitive online content. The project's goals include creating STEM MOOCs that clearly explain real-world applications of STEM concepts and providing training sessions for educators to produce inclusive online content. Deliverables of the project include a report on best practices for achieving gender balance in MOOCs, toolkits for developing inclusive courses, new MOOC courses designed in partnership with experts, and training sessions focused on inclusive teaching strategies.

Additionally, the FOSTWOM project aims to disseminate its results widely through conferences, webinars, and public presentations. In this work, we discuss the use of the Heroine's Learning Journey (HLJ) framework, which seeks to motivate young women to enter and persist in STEM fields. The HLJ is designed to empower young women, particularly those between 15 and 21, by improving their STEM skills and fostering a sense of belonging in these fields. The framework uses a narrative-driven approach to engage learners and provide them with role models reflecting their experiences. We present the evaluation of the HLJ model conducted by 12 teachers and MOOC content experts involved in the FOSTWOM project. The evaluation results provide valuable insights into how educators can use the HLJ to design gender-sensitive MOOCs that effectively address the challenges women face in STEM. In addition to expert evaluations, this work presents feedback from students who participated in the HLJ-based courses. These evaluations highlight the impact of the HLJ on students' motivation, engagement, and self-regulated learning, particularly at critical stages such as Stage 10, *Self-Regulated Learning*. We explore how experts and students perceive the motivational aspects of HLJ stages and the lessons learned from their evaluations, which contribute to the ongoing development of gender-sensitive STEM education frameworks.

Remark: This article is an extended and revised version of the paper entitled "STEM Education for Young Women via Heroic Narratives: Evaluating the Heroine's Learning Journey" (L. F. Costa et al., 2024), initially presented at the *Simpósio Brasileiro de Educação em Computação* (Brazilian Symposium on Computing Education) – EduComp 2024, awarded Best Paper, and subsequently invited for submission to the *Revista Brasileira de Informática na Educação (RBIE)*.

The document's structure follows: Section 2 discusses related research relevant to the HLJ and gender equality in STEM education. Section 3 provides a theoretical background on the Heroine's Learning Journey framework. Section 4 describes the methodology used for evaluating the HLJ. Section 5 presents the evaluation results, and Section 6 presents a detailed discussion. Finally, Section 7 concludes with reflections on the findings and suggestions for future research directions.

2 Related Work

To analyze data on female participation in Europe, the FOSTWOM Project has, for example, found that the percentage of young women studying computer science in the European Union was around 24% as of 2018, of whom only 60% pursue careers in the digital sector (Birch et al., 2018). The problem is exacerbated in digital and emerging technologies, such as artificial intelligence, where the gender gap is even more pronounced. According to the World Economic Forum, only 22% of AI professionals globally are women (World Economic Forum, 2022), highlighting a significant gender imbalance in one of the most crucial technological fields of our time. The exclusion of women from STEM limits the diversity of perspectives and approaches needed to solve complex problems, innovate, and drive technological advancement. Recognizing the field of computer science, particularly machine learning and data science, as crucial for current and future activities in the global society, the FOSTWOM project believes that women should have equal access to higher education and careers in these areas. Aligned with European policies that require capacity building and the development of innovative ways to connect STEM fields to society, the FOSTWOM project proposes to engage young women, attracting them to STEM disciplines in secondary and higher education, as well as related careers (Birch et al., 2018). Girls and young women should be encouraged in STEM education, as they have an equal right to understand how the field can positively impact the world (Jacqmin, 2021). Jacqmin (2021) states that discrimination, biases, social norms, and expectations hinder young women's education quality. Female contributions are crucial to advancing sustainable development (Jacqmin, 2021).

In line with these challenges, we highlight research by Reis et al. (2023), which explores developing a strategy to incorporate issues related to gender identity into an introductory computing course. Their methodology has 13 phases and has been implemented since 2019. The primary objective is cultivating computational, critical, and systemic thinking skills. The course is organized on the Moodle platform, where each phase represents a topic comprising a narrative, a challenge, instructions, and a survey. Student activities are submitted online, and a portfolio is created within the *Delivery Forum*. The teaching approach involves a flipped classroom model, encompassing pre-class, in-person class, and activity-review segments. Student progress is assessed using XP, with a cumulative total of 100 XP. In Phase 13, self-assessment converts XP into a final grade, calibrating scores achieved in phases 01 to 12. Integrating a gender perspective into the course was achieved by selecting two fundamental themes pertinent to the feminine context. These themes, namely female empowerment and discrimination against women, align directly with the objectives delineated in the United Nations' Sustainable Development Goal 5. The course content's structure was meticulously crafted to address these gender issues transversally throughout all its phases. This holistic approach emphasizes the crucial importance of fostering awareness and in-depth understanding of gender issues from the initial stages of the computing curriculum, thereby establishing a solid foundation for developing professionals who are conscious of and engaged with gender equity in the technological field. The integration of gender perspectives in computing education, as discussed above, finds practical application in various initiatives aimed at addressing the gender gap in technology.

One noteworthy effort is highlighted in the research conducted by Paganini and Gama (2020), which examines strategies for creating more inclusive environments in technological spaces, particularly hackathons. The Hack Grrrl project, a focal point of this research, exemplifies a targeted approach to enhancing female participation in these traditionally male-dominated events. This initiative has created more inclusive and appealing environments for female participants by identifying and addressing the distinct motivational factors influencing women's engagement in hackathons. The efficacy of the Hack Grrrl project underscores the potential impact of tailored interventions in promoting gender equity within technological spheres. By providing women with supportive environments specifically designed to accommodate their needs and preferences, these initiatives offer valuable opportunities for skill development and talent showcase. This approach aligns with the broader goals of female empowerment and non-discrimination outlined in the UN's Sustainable Development Goal 5 and represents a concrete step towards narrowing the gender gap in technology fields. Other significant efforts, such as the *Meninas Digitais* program, aim to promote gender equality in STEM by introducing young women to Computer Science through hands-on experiences and mentoring relationships (Maciel et al., 2018). Programs like *Meninas na Ciência* also emphasize the importance of practical workshops and research projects in igniting young women's interest in STEM fields, with long-term goals of encouraging their pursuit of careers in Science and Technology (Sacchelli et al., 2016).

To find scientific evidence, L. F. C. Costa, Nascimento, et al. (2024) reviewed the barriers and motivators that influence women's participation in STEM in Brazil, particularly in Engineering and Computer Science. Barriers include societal stereotypes, isolation in predominantly male fields, and a lack of institutional support. In contrast, motivators include early exposure to STEM, family support, and environments that promote gender inclusivity. The study highlights the importance of role models and STEM competitions as strategies to increase young women's engagement in STEM. In another study on initiatives that encourage women's participation, Abreu et al. (2024) discusses gender equality initiatives in Latin America, focusing on Brazil. The study emphasizes the importance of hands-on, practical workshops in increasing women's confidence and interest in STEM fields. The need for broader cultural changes is also stressed, as structural gender biases in technology remain a significant barrier to equal participation. Finally, L. F. C. Costa, Gomes, et al. (2024) explores the effectiveness of narrative learning environments, such as the Heroine's Learning Journey, in promoting women's engagement in STEM through MOOCs. Using heroic narratives increases motivation and persistence in online learning, particularly by offering relatable role models and stories that align with learners' experiences, helping them overcome gender-related challenges.

3 The Heroine Learning Journey

The Heroine's Learning Journey (shown in Figure 1) is a learner-centered methodology around the Heroine. Character-centered learning Journeys focus on using stories or fictional characters to help students understand complex concepts in a more accessible and memorable way. In this context, the HLJ serves as a narrative for STEM students' internal challenges as they strive to overcome their fears and challenges in the educational environment, ultimately becoming learner heroines. The HLJ aims to empower young women, primarily between the ages of 15 and 21, by helping them improve their skills and motivating them to continue their studies. This empowerment of young women is achieved by guiding the acquisition of new skills and knowledge, presenting inspiring role models, and supporting the confidence and self-regulation of young learners. The HLJ was developed as a methodology to address the challenge of low female participation in STEM fields.

The Heroine's Learning Journey is divided into 3 acts and 12 stages. A brief description of each stage is provided on the Heroic Journeys' website[1], and below, we present the 3 acts:

1. **Act I - Empowerment (Stages 1-5):** In the initial phase, the learner must face the challenge of transitioning from their ordinary world, acknowledging the present state of their beliefs, to a new realm that promises fresh insights and life perspectives. This stage employs motivational strategies to enhance confidence and convert fear into strength. The outcome of Act I is the emergence of an empowered learner.

[1]https://heroicjourneys.life/journey-heroine/

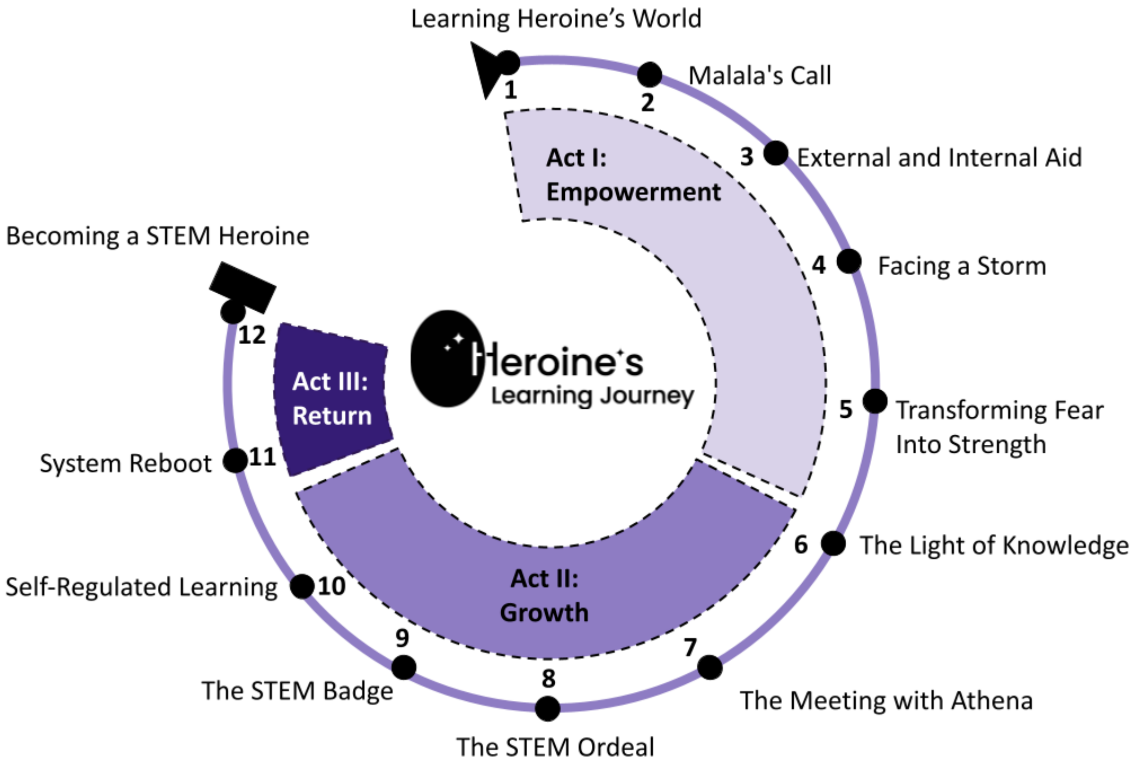

Figure 1: The Heroine's Learning Journey Acts and Stages.

2. **Act II - Growth (Stages 6-10):** The second act encapsulates the journey, facilitating skills acquisition. If necessary, the learner is encouraged to identify and collaborate with allies to surmount diverse tests and challenges, ultimately attaining a rewarding outcome for their dedicated efforts. Throughout Act II, students evolve into a renewed and improved version of themselves. These observations are corroborated by the thematic analysis of the reflective reports collected in Stage 10. Although a formal pre-intervention measurement was not conducted, the final reflective reports indicate a significant improvement in students' self-regulation skills and motivation. Should the need arise, stages 4, 6, 8, and 9 can be revisited to optimize the course structure, supporting subtopics or extended programs.

3. **Act III - Return (Stages 11-12):** The third act is characterized by a definitive transformation and recognition of the learner as true heroines. These heroines subsequently extend their support to other learners embarking on their journeys. Act III culminates in the Heroine's return, equipped to assist other young women.

We highlight that while some courses may opt not to depict students as heroines in subsequent editions, it is essential to provide students with an opportunity to reflect on their learning. Consequently, stages 11 and 12 can alternatively be implemented by soliciting a learning report, in which the learner delineates their acquired knowledge and narrates their journey. For each stage, we define four primary characteristics: Challenge, Mission, Story, and Aid. On the other hand, the learning structure at each stage involves planning, learning, and reflecting on the progress of skill acquisition (L. F. C. Costa, 2023). The narrative features a central conflict, encounters with fictional characters, underlying mysteries, and many other details, most of which have previously been used as motivational tools in education (Bell, 2017). Feedback moments are designed to strengthen students' confidence and enhance their additional motivation (R. Ryan, 2019; R. M. Ryan & Deci, 2019). The epic scenario provides intrinsic motivation (McGonigal, 2011). The HLJ is inspired by the Hero's Journey (Campbell, 2008) and the Heroine's Journey (Murdock, 2020), and it follows the traditional three-act structure (Thompson, 1999), consisting of twelve stages.

HLJ integration into courses occurs by directly combining theoretical content with narrative elements in the curriculum structure. For instance, Stage 1 ("Learning Heroine's World") introduces foundational concepts alongside a narrative that challenges preconceptions. In contrast, Stage 5 ("Transforming Fear into Strength") aligns practical assignments—such as algorithm implementation—with reflective tasks that reinforce technical skills. This deliberate articulation ensures that HLJ supports the course's motivational and academic objectives.

The HLJ uses, besides Narratives, several motivational theories, including Self-Determination Theory, Project-Based Learning, and Self-Regulated Learning (L. F. C. Costa, 2023). We briefly explain these motivational theories:

- **Self-Determination Theory** (SDT) was proposed by Ryan and Deci (R. M. Ryan & Deci, 2019) as an empirically-based organismic theory of human behavior and personality development. The theory emphasizes the importance of competence and autonomy as key elements. When these needs are met, intrinsic motivation can arise; when they are not, it is undermined (R. M. Ryan & Deci, 2019). Intrinsic motivation is associated with pursuing novelty and challenges, aiming at exploration and learning, which can lead to creativity, task performance, and optimal experience (Di Domenico & Ryan, 2017; R. M. Ryan & Deci, 2019). In educational settings, intrinsic motivation is crucial in high school (Froiland & Worrell, 2016; Taylor et al., 2014) and higher education, including STEM fields and women's education (De Loof et al., 2021; Moore et al., 2020; Müller & Palekčić, 2005; Skewes et al., 2018; Wang et al., 2020; Williams & Deci, 1998). According to Chua et al. (2021), "the progress of our goal pursuit is influenced by what we do and what we receive". The importance of goals and their relationship with student performance has been studied in education (Benita et al., 2014, 2017, 2021; Chua et al., 2021). Additionally, online learning environments, which play a significant role in attracting students, have also been explored in the application of SDT (Chen & Jang, 2010; Chiu, 2021, 2022).

- **Project-Based Learning** is a comprehensive teaching approach that engages students in investigation (Blumenfeld et al., 1991). Within this framework, students seek solutions to non-trivial problems by asking and refining questions, debating ideas, making predictions, designing plans or experiments, collecting and analyzing data, drawing conclusions, communicating ideas and findings to others, asking new questions, and creating artifacts. However, implementing it requires a skilled teaching force (Capraro et al., 2013). Project-based learning in STEM fields focuses on measurable outcomes and can improve students' cognitive profiles and social skills, aligning with the demands of STEM careers (Capraro et al., 2013; Tadjer et al., 2022). Project-based learning allows for the identification of different moments when students must perform various tasks, thereby playing a vital role in breaking down student activities into stages. Project-based learning has been extensively investigated and applied in software engineering education programs to improve students' cognitive profiles and social skills, aligning with the current demands of STEM careers that require social abilities such as communication, analysis, problem-solving, and teamwork (Tadjer et al., 2022).

- **Self-regulated Learning** refers to processes that students employ to transform their mental abilities, such as verbal aptitude, into academic performance skills, such as writing, to establish goals, select and deploy strategies, and self-monitor their effectiveness (Zimmerman, 2008). Zimmerman's Cyclical Model of Self-Regulated Learning divides students' learning processes and motivational beliefs into three self-regulatory phases: Forethought, Performance, and Self-reflection (Zimmerman, 2008). This model aligns with the separation of activities in project-based learning approaches, as activities in such courses can be categorized into these three self-regulatory phases. Zheng et al. (2023) proposes five cognitive processes of self-regulated activities: observation, formulation, reformulation, analysis, and evaluation. They indicate that reformulation and analysis are two self-regulatory activities that can improve learning. However, excessive observation, which can be mapped to self-reflection (Zimmerman, 2008), may hinder learning (Zheng et al., 2023).

To implement the HLJ model in a STEM course through integration, we have developed the Heroine's Learning System (HeLaS). HeLaS is a web application that allows educators, tutors, and educational teams to create and manage course materials in accordance with the methodology set by the HLJ. Specifically, HeLaS provides a way to develop materials for a course that follows the HLJ and integrate these materials into an existing Learning Management System (LMS), blending the information the LMS displays with display elements provided by HeLaS. The HeLaS diagram composed of all its modules is shown in Figure 2.

We make the HeLaS framework available on the Heroic Journeys' website. In this portal, we present concepts related to Heroic Journeys and provide the HLJ application framework in an agile and easy-to-use manner, containing instructions for use. The framework functions as an essential support system for educators, tutors, and educational staff, providing all the necessary elements to associate the candidate course with the stages of the journey. In addition to these usage instructions, we also introduce the roles played in applying the model. Among these roles, one noteworthy character is Athena, a fictional character who assists students throughout their journey. Athena provides crucial knowledge and information for the success of the Heroine candidate. Athena also represents Stage 7, *The Meeting with Athena*. Unlike other allies, Athena embodies the sharing of knowledge and serves as a source of wisdom. The guidance this character provides always offers accurate information, essential tips, and direct access to relevant knowledge in the field of study. Athena is not only a symbolic figure of wisdom but is carefully integrated with the technical content to serve as a relatable role model, enhancing the discipline's contextual relevance to female students.

Adapting HLJ to a candidate course enables the integration of the course's didactic content into a separate infrastructure distinct from the MOOC platform. The total time for information registration and combination in HLJ is estimated to be 2 to 5 hours, depending on the number of topics and course activities. The registration process can be carried out in stages and at different times, as information is saved in the database after each step. A Journey Designer is responsible for

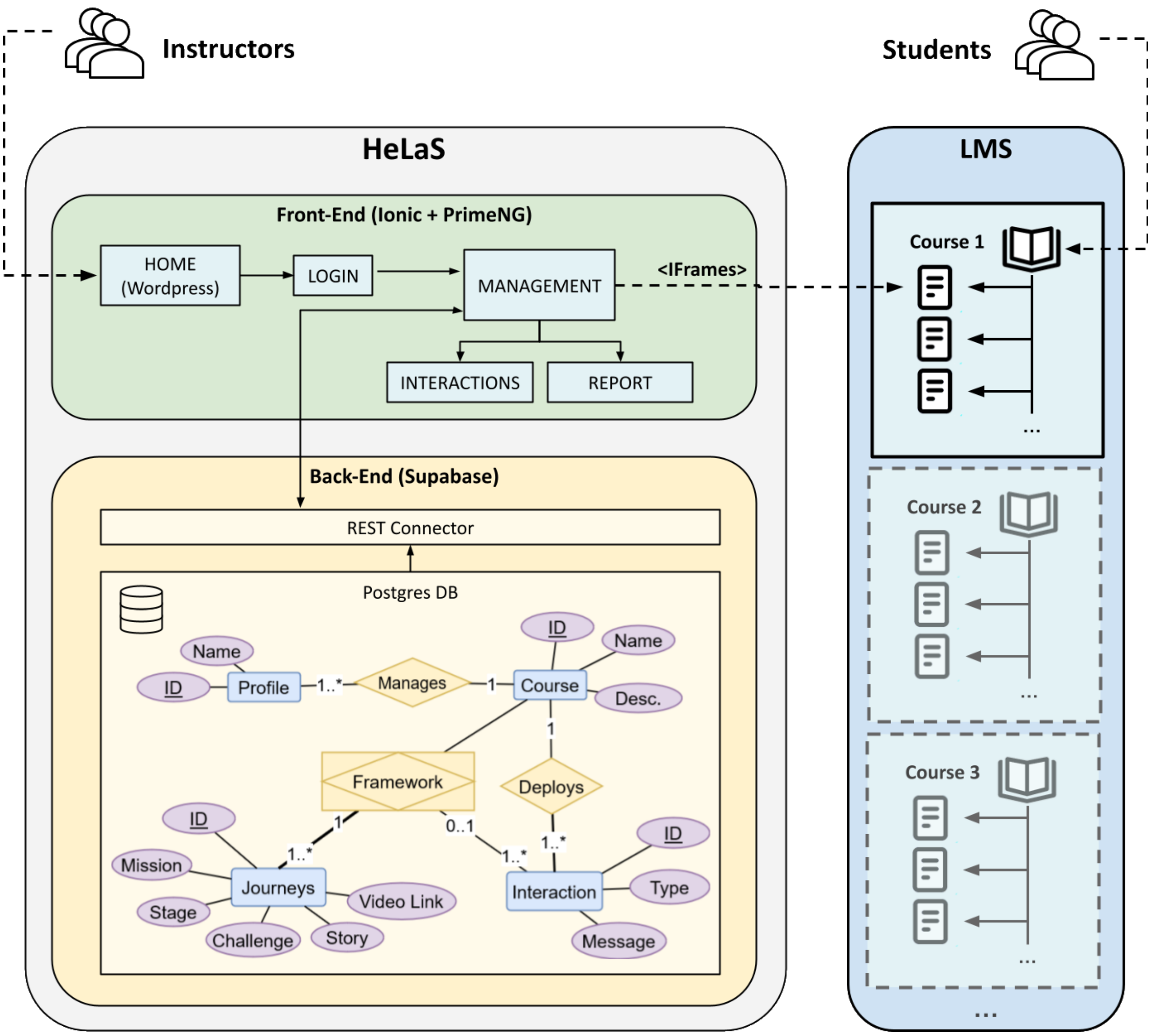

Figure 2: The HeLaS Diagram.

structuring and translating the course contents into the HLJ framework, ensuring alignment with the journey's motivational stages. Ideally, the course instructor should receive specific training to perform this role effectively. Alternatively, instructors can collaborate with an HLJ specialist to support the transformation of the course content into a journey. The HLJ also offers optional roles called Allies, who are subject-matter experts and can participate in additional activities to support students, such as mentoring via the Discord app. The Discord app allows students to communicate instantly by exchanging text, audio, and video messages. Allies can also conduct extra classes, such as practical or pre-scheduled discussions, as informed by students. Another role offered by HLJ is a Tutor. Those with this role have a higher hierarchy than Allies, with the same rights but greater responsibilities. They are responsible for dedicating themselves throughout the course to supporting students on the online teaching platform, addressing doubts in the forums, and assisting with specific exercises in the Discord group. Each step includes a help link that provides instructions for registering at each stage, ensuring a clear understanding of the information-filling process. Figure 3 presents examples of a course structured with the framework's support and examples of HLJ elements.

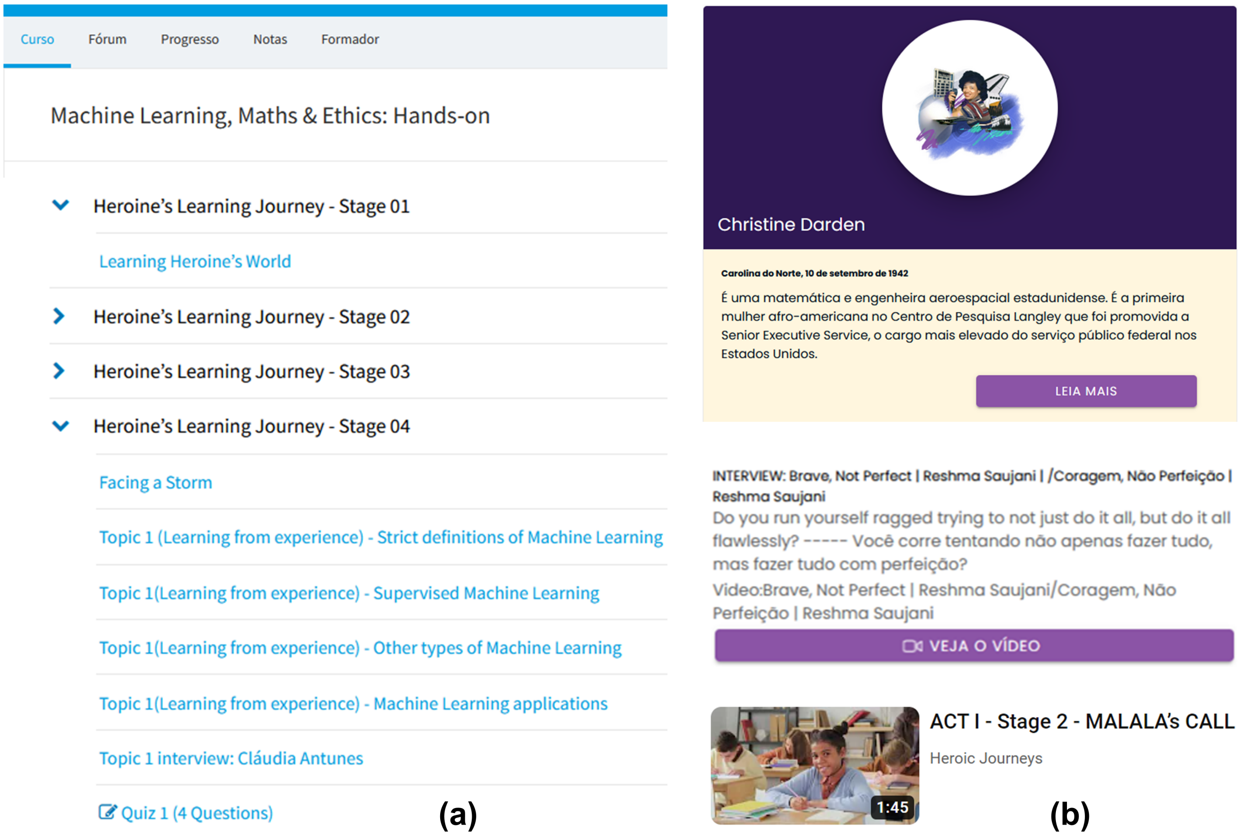

Figure 3: Course restructured with the HLJ model: (a) course structure with the stages, and (b) some of the elements of the HLJ inserted.

To illustrate the deep integration of HLJ with disciplinary content, consider its application in a Machine Learning course. In this context, each of the 12 HLJ stages begins with a motivational video specifically designed to inspire students, set the emotional tone, and provide narrative context for the subsequent activities. After viewing the video, students proceed to course modules deliberately aligned with each HLJ stage, addressing specific learning objectives through technical and reflective tasks. The original course content is integrated into the 12 stages of the HLJ, with specific activities for each phase.

For example, during Stage 1 ("Learning Heroine's World"), the motivational video introduces a narrative that is further developed in an introductory lecture presenting fundamental machine learning concepts, challenging students to recognize and overcome initial misconceptions about the field. Similarly, Stage 5 ("Transforming Fear into Strength") begins with a motivational video that prepares students emotionally and cognitively for practical assignments where they implement basic algorithms, effectively converting theoretical challenges into applied learning experiences. Throughout the course, thematic prompts and reflective tasks are consistently interwoven with technical content, ensuring that the HLJ framework is not merely interleaved with the curriculum but structurally embedded to reinforce motivational and academic outcomes.

4 Methodology

The main goal of the HLJ is to support young female students aged 15 to 21, a critical age range for making career decisions. The first assessment involved students enrolled in the course on Machine Learning, Mathematics, and Ethics and evaluated each of the 12 motivational videos corresponding to the HLJ stages. In the second edition of the course, which integrated the HLJ model, there were 368 enrollments, with female participants comprising approximately 59.2%—the highest percentage recorded on the MOOC Técnico platform. Among them, 46.3% were within the target age group of 15 to 21, while 57.8% were between 15 and 22 years old. Finally, 67 students obtained an honor certificate, representing 18.2% of participants.

During the student evaluation process, students could rate each video associated with the 12 stages of the HLJ using a star system, ranging from 1 to 5 stars. These ratings were collected anonymously through the MOOC platform, which integrated the HeLaS infrastructure, allowing students to submit their evaluations before starting the stage activities. The goal was to gather insights into how students perceived each video's motivational impact and overall experience during the course. A total of 362 evaluations were collected, and the rating distribution was uneven, with more ratings submitted in the earlier stages than in the later ones.

The second evaluation focused on Stage 10 of the HLJ, titled "Self-Regulated Learning," which introduced students to self-regulation in their learning process. In this stage, students were tasked with submitting a final learning report, reflecting on their journey throughout the course. This reflection was aligned with Zimmerman's cyclical model of self-regulation, which involves the phases of Forethought, Performance, and Self-reflection. From the reports submitted (n=35), 28 were included in the analysis. The thematic analysis of these reflective reports focused on key areas: Skills and Knowledge Acquired, Motivation and Engagement, Personal and Professional Impact, and Challenges and Obstacles. This qualitative feedback provided deeper insights into the students' internalization of the learning process and self-regulating ability. Although no formal pre-intervention assessment was conducted to measure students' quantitative evolution, comparing the initial video evaluations with the final reflective reports allows us to infer improvements in learning strategies. In future implementations, we plan to incorporate explicit pre- and post-intervention evaluations to quantify this evolution more precisely.

In addition to the student evaluations, the third and most comprehensive assessment was conducted by 12 experts (e.g., Professor, Researcher, Media Producer, Instructional Designer, and Pedagogical Coach) from the FOSTWOM project. These experts participated in a workshop to evaluate all 12 stages of the HLJ from an educational and motivational perspective. The expert evaluations were carried out using a combination of Likert-scale ratings and qualitative feedback, focusing on assessing each stage's ability to engage and motivate young women to pursue STEM careers. This evaluation aimed to identify strengths and areas for improvement in the HLJ model, offering valuable insights for future iterations of the course design.

The evaluations of student video ratings, reflective reports from Stage 10, and expert assessments provide insight into the effectiveness of the HLJ in motivating and engaging young women in STEM. While the student evaluations highlighted the stages' immediate impact on learning and engagement, the experts offered a perspective on the educational design. These complementary assessments form the foundation for the discussion presented in this article.

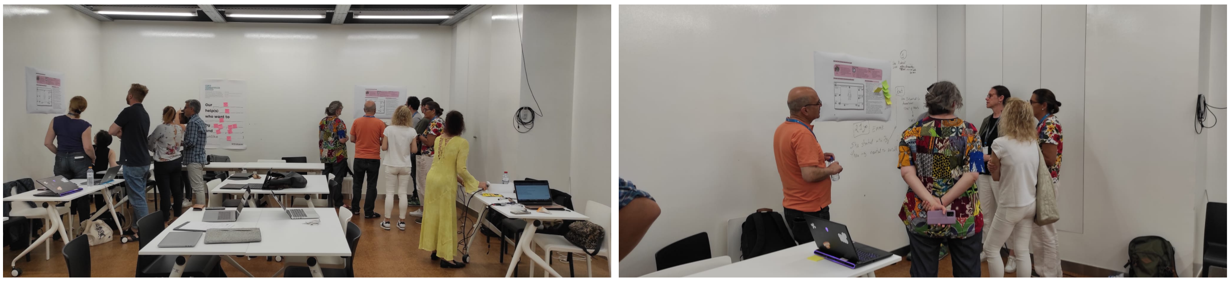

Figure 4: Group of educators analyzing a HLJ stage (left) and Environment organization (right).

The reliability of self-report measures in assessing self-regulated learning is well documented in the literature. For example, Zimmerman (2008) demonstrated that self-report instruments effectively capture the cognitive and motivational processes underlying self-regulation, a finding further supported by studies such as Zheng et al. (2023). Although self-reports may be subject to biases, they provide valuable insights into internal processes that are difficult to observe through other instruments.

Concerning the FOSTWOM's workshop, the main objective of the three-day training session was to discuss strategies for using STEM MOOCs, employing the flipped classroom method (Bishop & Verleger, 2013; Lima & Carvalho, 2021), to increase awareness of gender inclusion in online academic content. While we did not implement a formal quantitative measure of awareness, the workshop was designed to foster in-depth discussions and reflections on gender inclusion. Qualitative feedback collected through open-ended questions and post-session evaluations indicated that participants had a better understanding of gender-related issues. In future iterations, we plan to incorporate explicit pre- and post-workshop assessments using validated instruments to quantitatively measure changes in awareness. The "Challenges and Motivational Approaches: Heroine's Learning Journey" evaluation session aimed to assess the HLJ and its 12 stages conceptually, as shown in Figure 4.

We created an online module to share content and discuss topics on the University of Lisbon's Technical MOOC platform, and all experts were required to register in advance for the face-to-face sessions. We provided them the video presenting the HLJ – from "PASC22 Conference" (2022) – the poster presented at the 1st Pedagogical Conference of the University of Lisbon (Santos et al., 2022), and an article about the Brazilian case of gender equality initiatives in education (L. Costa et al., 2020). During the workshop, the activities began with the organizers' personal and institutional introduction, followed by an overview of the event's agenda and individual introductions of each participant. Next, we provided an overview of the current state of gender equality in STEM, including data on women's barriers to entering and remaining in the field. Then, we conducted a persona development exercise for the HLJ target audience. We divided the participants into two teams, each responsible for creating a persona for one of the age extremes for which the HLJ was developed. We characterized the 12 workshop participants through the questionnaire to assess their demographic and professional characteristics, as shown in Table 1.

Afterward, we presented the motivational theories used by the HLJ, including Self-Determination Theory, Project-Based Learning, and Self-Regulated Learning and Narratives (L. F. C. Costa, 2023). The heroic journey was presented, including the roles, narrative, and the process/software for adapting a course with the journey. A student's journey in a course applying the HLJ was then presented and evaluated. The group was divided into two teams again to assess the journey based on their respective persona.

Participants completed a questionnaire section at each journey stage, as shown in Table 2. They watched a video of the stage, accompanied by narrative, mission, challenge, and support information as needed to complement the video. At the end of the stage evaluations, participants were asked to assess the HLJ as a whole, answering the questions presented in Table 3. Finally, the activity concluded with a farewell, announcements about future interactions, and collecting feedback.

5 Results

This section presents the results of the FOSTWOM Experts' and the Students' Evaluation.

Table 1: Demographic and professional characteristics questions.

Section	Question	Type
Demographic	In which country do you reside?	Open
	What is your age?	Open
	What gender do you identify as?	Closed (Female/ Male/Other/Decline)
Professional Experience	What is your current position?	Open
	Where do you currently work?	Open
	How long have you been working in the Education sector? (in years)	Open
	Do you work in the STEM sector?	Closed (Yes / No)
	How long have you been working in the STEM sector? (in years)	Open

Table 2: List of questions made at the end of each HLJ Stage.

Question	Type
I LIKE! (things you find remarkable about this step of the HLJ)	Open
I WISH... (things you wish were different about this step of the HLJ)	Open
Please rate the following statement: "I believe that this step of the HLJ is important to motivate women to participate in a STEM course."	Likert
Please rate the following statement: "I believe this step of the HLJ needs to be improved to achieve the goal of motivating women to participate in a STEM course."	Likert

Table 3: List of questions made at the end of the session "Challenges and Motivational Approaches: Heroine's Learning Journey".

Question	Type
Please rate the following statement: "I believe the HLJ, as a whole, has great potential to motivate women to participate in a STEM course."	Likert
How would you evaluate the workshop?	Closed (1-5)
What did you like the most about the workshop?	Open
What did you like least about the workshop?	Open
Would you like to leave any suggestions for future workshops?	Open

Table 4: Demographic and professional characteristics of the participants.

Position	Country	Age	Gender	Education Experience	Works in STEM	STEM Experience
Professor	Portugal	46	Male	14	Yes	23
Assistant Professor	Portugal	47	Female	23	Yes	23
Researcher	Italy	38	Male	8	Yes	10
Assistant Professor	Spain	57	Female	33	Yes	33
Assistant Professor	Portugal	47	Female	25	Yes	25
Media Producer	Sweden	57	Male	20	Yes	8
Instructional Designer	France	58	Female	10	Yes	5
Instructional Designer and Project Manager	Italy	30	Female	6	No	N/A
N/A	Sweden	35	N/A	10	Yes	10
Assistant Professor	Spain	57	Female	33	Yes	33
Instructional Designer	Italy	32	Female	7	No	N/A
Pedagogical Coach and Video Coach	Sweden	57	Female	34	Yes	2.5

5.1 FOSTWOM Experts' Evaluation

The 12 participants of the workshop completed the questionnaire. An initial set of questions was asked to better understand the participants in terms of demographic and professional characteristics. The responses to this set of questions are presented in Table 4. We highlight that the participants mainly hold positions as teachers and educational content developers in universities from four European countries. The female gender is predominant, with 8 participants, followed by three males and one who declined to answer. All participants have at least six years of experience in education, with an average of 18.5 years. Lastly, 10 participants who work with STEM have a minimum of 5 years of experience and an average of 17.3 years.

During the workshop, participants were asked to answer four identical questions for each of the 12 stages of the HLJ. Two of the questions were qualitative, requiring free-text responses. The first of these questions asked participants to mention what they liked about the video for that particular stage of the HLJ, while the second question aimed to gather suggestions for improvements for each video. Table 5 presents the responses to each question for the 12 stages. The other two questions were quantitative and asked participants to indicate their level of agreement with a specific statement using a Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The statements were: "I believe this stage of the HLJ is important for motivating women to participate in a STEM course" (Figure 5 - left) and "I believe this stage of the HLJ needs improvement to motivate women to participate in a STEM course effectively" (Figure 5 - right). We highlight that the last question has reversed values – i.e., strongly disagree is the "best" answer. We use this valuation to reduce the effects of acquiescence. Acquiescence is a common response bias related to an individual's tendency to agree with a statement regardless of its content (Vigil-Colet et al., 2020).

Figure 5 (left) shows that in terms of motivation capacity, all stages received a minimum of 60% positive ratings (options 4 and 5), and at least 75% of ratings indicated no disagreement with the motivational impact (options 3, 4, and 5). Stages 1, 4, and 5 have over 83% agreement. Meanwhile, Figure 5 (right) shows that in terms of the need for improvement, the higher the agreement, the greater the need for improvement for the evaluated stage. In this case, 9 out of the

Table 5: Examples of responses to the “I Like” and “I Wish” questions.

Stage	“I Like!”	“I Wish…”
1	The effort to know the target public and understand what captures their attention	I wish the video explained her story better
2	I really like the video because it makes me believe in myself and that I can succeed in a STEM field	Maybe more details on course content
3	I like this video because it makes me feel like I have lots of learning possibilities and that there will be people ready to help me	I wish the self-knowledge path were clearer with examples and tools
4	I like this video because it shows that there will be initial difficulties, but they can be overcome	More tips about time management should be given
5	I liked the mention of the importance of finding balance and knowing how to compromise	I wish I could have gotten some hands-on tools on how to cope with fear
6	I like this video because I'm an influencer, and I think knowing that there's a community of women is important	I wonder if reality is that "easy and happy"?
7	This is me! I have all of these attributes! I am Athena!	I would prefer that the conditions to reach the reward were thoroughly enumerated
8	I like the power of the video: it let me understand that the journey is long, but I can overcome it	Maybe how to increase my self-confidence, how to do it?
9	"Success and comfort can't coexist": I like this sentence because it pushes me to go out of my comfort zone	To know how to manage the pressure and improve self-confidence
10	I like to understand how the feeling of fear is a "normal feeling": it helps me start reflecting on that feeling and how to overcome it	The presence of the explanation of self-regulated means
11	This is really important – the ethical perspective – to put science to good use	I wish the title reflected more on the idea. Maybe restart (cycle idea) and not reboot (starting from scratch). It also seems to have a lot of mixed ideas.
12	I like this video because it made me feel that I can accomplish something, be a role model, and shape a better world	I wish the video had a distinct message from the previous one

12 stages received at least 50% neutral or disagreeing ratings regarding the need for improvement. Stage 6 needed the most improvement, with 75% agreement with the statement. Stages 3 and 11 also deserve attention, with 58.4% of ratings indicating a need for improvement.

At the end of the stage evaluations, participants were asked to assess the HLJ as a whole, agreeing or disagreeing with the statement: "I believe that HLJ, as a whole, has great potential to motivate women to participate in a STEM course." The result of this question shows that 66% of respondents fully agree (8%) or agree (58%) with the statement that HLJ has excellent potential to motivate women to participate in a STEM course, as shown in Figure 6. No participant selected the option "strongly disagree" when evaluating the statement.

5.2 Students' Evaluation

This section presents the results of the Students' Evaluation. First, we present the evaluation of the videos shown to students at the beginning of each stage. Next, we present their qualitative evaluation, Self-Regulated Learning, Stage 10 of the HLJ.

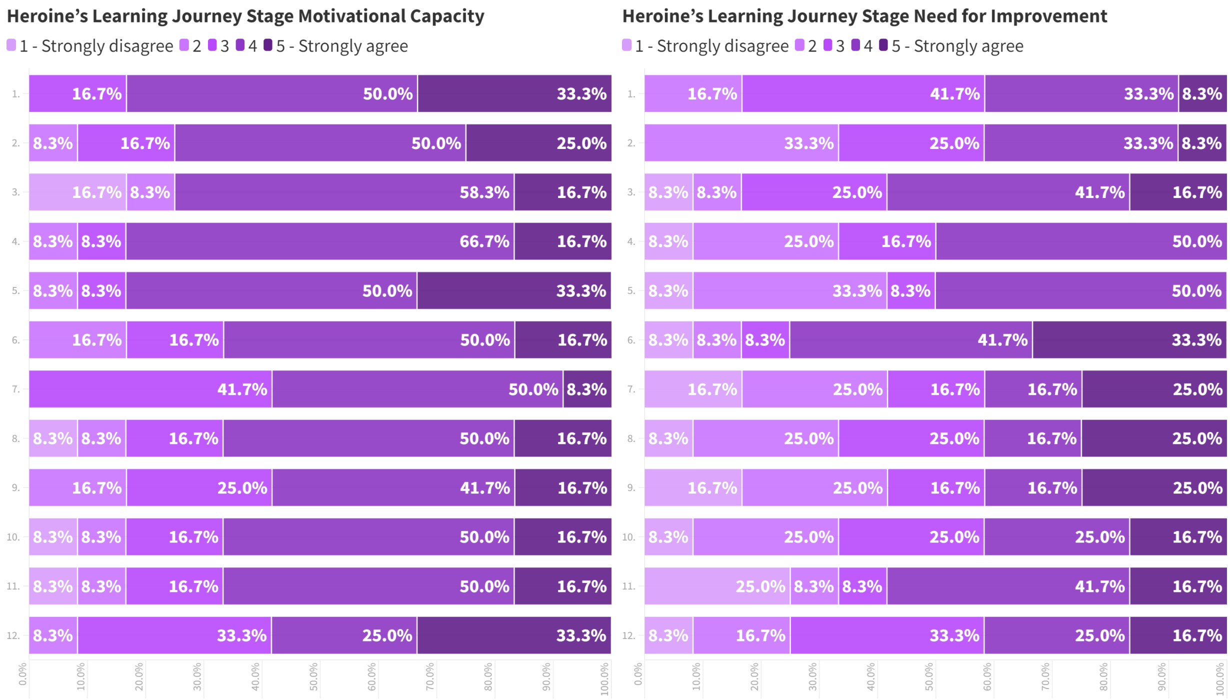

Figure 5: Evaluation of Motivational Capacity (left) and Need for Improvement (right) by Stage.

5.2.1 *Evaluation of Stage Videos*

In this evaluation phase, students were invited to rate the 12 stages of the HLJ as part of their experience in the Machine Learning, Mathematics, and Ethics course. Each stage was associated with a video, and students could anonymously rate each video using a star system (1 to 5 stars). This rating system was integrated into the MOOC platform via the HeLaS infrastructure, allowing students to rate a stage's video before starting its activities. These evaluations were optional, and students could proceed without submitting a rating. Table 6 shows the ratings per stage. Stage 1 received the highest evaluations (67), while Stage 9 had the fewest (13). A possible explanation

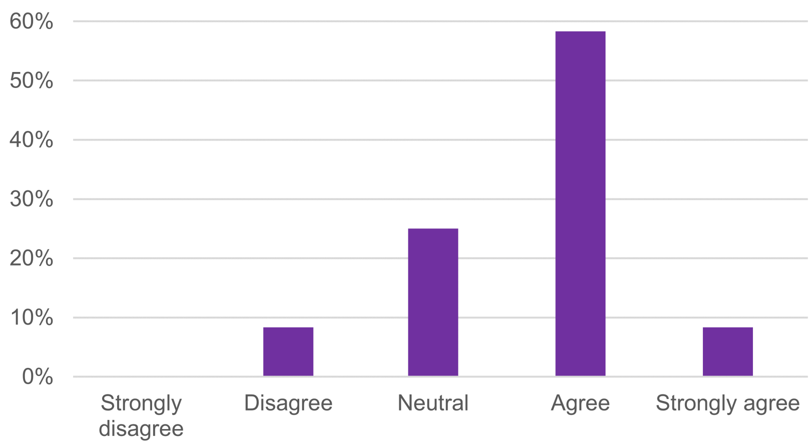

Figure 6: Agreement with the statement "I believe that HLJ, as a whole, has great potential to motivate women to participate in a STEM course".

Table 6: Rating distribution per Stage Video.

Stage Video	Rating					% Ratings 4 and 5	N (Total Respondents)
	1	2	3	4	5		
1	1	2	3	6	55	91%	67
2	0	0	4	7	47	93%	58
3	1	0	3	11	35	92%	50
4	1	0	5	4	37	87%	47
5	0	0	2	3	18	91%	23
6	0	0	2	1	15	89%	18
7	0	1	1	1	14	88%	17
8	0	0	1	1	17	95%	19
9	0	0	0	2	11	100%	13
10	0	0	1	1	14	94%	16
11	0	0	0	3	16	100%	19
12	0	0	0	2	13	100%	15
Total	**3**	**3**	**22**	**42**	**292**	**94%**	**362**

for the discrepancy is that students provided ratings as they progressed through the stages, and not all students reached the final stages or completed all of them. In total, 362 ratings were submitted across all videos.

The ratings distribution across stages was not uniform, with earlier stages receiving more ratings and later stages receiving fewer. Among these, two videos received a rating of 1 star, three videos received 2 stars, and eighteen videos received 3 stars. The majority of ratings, however, fell between 4 and 5 stars, as illustrated in Table 6. The overall average rating across all stages was 4.7, reflecting a generally positive reception of the HLJ videos by the students. The evaluations of the stage videos were positive, as shown in Table 6.

5.2.2 Evaluation of Stage 10: Self-Regulated Learning

In addition to the quantitative evaluation of the videos, a qualitative assessment was conducted during Stage 10, *Self-Regulated Learning*, of the HLJ. This stage required students to submit a final learning report, reflecting on their experiences throughout the course. Students were tasked with applying self-regulation principles by providing a detailed reflection on their learning process and progress.

The learning reports reflect distinct approaches to self-regulated learning. One participant emphasizes technical skill acquisition: “Throughout this course, I learned a lot about machine learning implementation resorting to Python. I felt that the examples were simple but effective and the explanations videos were really good just like the extra notebooks”. This reflection highlights the effectiveness of practical resources, such as hands-on exercises and instructional materials, in fostering learning engagement. The participant also connected their experience with the heroine’s journey, noting that “while being a mechanical engineering student, it is a really good initiative”. This remark suggests an appreciation for the program’s role in broadening participation in STEM fields. Beyond technical learning, the participant acknowledges the importance of diversity in engineering, stating: “As it was said during the course, it is important to have more female engineers in the world because in some tasks a female point of view may solve problems". This observation reveals an awareness of the broader implications of representation in technology, reinforcing the idea that diverse perspectives contribute to more effective problem-solving. However, the argument remains somewhat implicit, lacking further elaboration on how gender diversity directly impacts engineering outcomes.

In contrast, the second report shifts focus from technical implementation to conceptual and ethical considerations, stating: "Deepened my machine learning process knowledge. Learned new interesting facts related with the world of AI and ML, specially related with gender representation and ethical concerns". This participant engages with issues beyond coding and algorithmic proficiency, instead reflecting on the societal impact of AI and ML. The mention of gender representation and ethical concerns suggests a critical engagement with the biases embedded in technological systems, an essential aspect of responsible AI development.

The stage was designed to align with Barry Zimmerman's cyclical model of self-regulation Zimmerman (2008). According to Zimmerman, self-regulation consists of three key phases:

- **Forethought**, where students engage in goal setting and strategic planning;
- **Performance**, where students apply strategies and monitor their progress;
- **Self-Reflection** involves assessing their performance and adjusting future strategies.

Stage 10 was the self-reflection phase, where students could evaluate their learning journey and make strategic adjustments for future challenges. Students (n=35) were asked to submit reflective reports, though only 28 were included in the final analysis, with 7 being discarded due to insufficient text or off-topic responses. The qualitative data was analyzed using thematic analysis, focusing on key themes such as *self-efficacy*, *learning strategies*, and *intrinsic motivation*. Table 7 summarizes the key findings from the analysis, focusing on students' reflections on their learning process.

As Zimmerman highlighted, the students' reflections clearly engage with self-regulatory processes. Many students reported an increase in their self-efficacy and the development of effective learning strategies. These findings suggest that integrating self-regulation principles into the HLJ curriculum contributed to the students' ability to reflect on their learning and adjust their approaches for future success.

In the reflection phase, the data in the report were also important for evaluating other elements. The reflective reports were also analyzed through thematic analysis, focusing on key

Table 7: Qualitative Analysis of Student Reflections in Stage 10.

Key Theme	Frequency	Example Quote
Self-Efficacy	21	"I feel much more capable of tackling complex problems, especially those related to Machine Learning".
Learning Strategies	17	"I learned how to effectively manage my time and approach problems systematically".
Intrinsic Motivation	15	"This course reignited my passion for STEM subjects, and I now feel more confident in my abilities".
Goal Setting	10	"The process of setting small goals for each stage helped me stay on track".

themes such as *Skills and Knowledge Acquired*, *Motivation and Engagement*, *Personal and Professional Impact*, and *Challenges and Obstacles*. These themes were identified based on the content of the students' feedback and aligned with the learning objectives of the HLJ, particularly in promoting self-regulated learning. The methodology for the qualitative analysis involved coding the responses and categorizing them into these primary themes. The objective was to assess how students engaged with the course content, how their motivation evolved, and how they perceived the impact of the course on their personal and professional growth. The results are presented in Table 8, showing a detailed breakdown of student feedback and the main themes identified from their reflections. Furthermore, we can present more detailed information on these four topics:

- **Skills and Knowledge Acquired (SKA)**: This theme was the most frequently mentioned in 18 of the 28 reports. Students reported substantial gains in machine learning concepts, ethical data handling, and Python programming. The reflections indicated that students

Table 8: Stage 10 - Self-regulated learning qualitative analysis.

ID	Feedback	Main Themes
1	Deepened knowledge about machine learning, gender representation, and ethics.	SKA
2	Learned machine learning process, found examples and tests very helpful.	SKA
3	Gained knowledge for future use, found the videos accessible and informative.	SKA
4	Inspired to pursue programming and data analysis; videos and course dynamics helped.	ME
5	Deepened machine learning knowledge, reflected on ethical concerns in technology.	PPI
6	Learned machine learning and ethics, recognizing data and women's importance in tech.	SKA
7	Gained technical knowledge on supervised learning, bias, and ethical challenges.	CO
8	Gained confidence and motivation from the course; inspired by women role models.	ME
9	Improved skills in data visualization and machine learning; inspired by course content.	SKA
10	Gained comprehensive machine learning knowledge and explored ethical challenges.	SKA, CO
11	Learned how to better organize strategies for execution.	SKA
12	Enjoyed the course and appreciated the support, especially as a female participant in STEM.	ME
13	Praised the course structure and found the quizzes helpful in guiding learning depth.	SKA
14	Learned machine learning concepts tied to ethics and found the course motivating.	SKA
15	Increased confidence in working with machine learning and strengthened love for data science.	ME
16	Gained knowledge in machine learning methodology and ethical data handling.	SKA
17	Learned machine learning processes and ethical handling of data in compliance with GDPR.	SKA
18	The course was challenging but empowering, entering the tech world with more confidence.	ME
19	Learned about Python libraries and ethical data handling, inspired by women in tech.	SKA, PPI
20	Overcame challenges through intensive focus and improved learning discipline.	CO
21	Demystified machine learning, gained knowledge about data and ethical implications.	SKA, CO
22	Found it an interesting experience, opening new opportunities.	ME
23	Loved the experience, appreciated the help from the instructor, Larissa, and hopes more women enter STEM.	ME
24	Found the course motivating, empowering, and inspiring to continue in STEM.	ME
25	Learned a lot about machine learning implementation and the importance of female engineers.	SKA
26	Learned essential aspects of machine learning, data protection, and ethics.	SKA
27	Learned new skills in technology, Python, and was inspired by strong women in STEM.	SKA, PPI
28	Gained a structured understanding of machine learning and ethical responsibilities, even as a proficient Python user.	SKA, CO

SKA: Skills and Knowledge Acquired; ME: Motivation and Engagement; PPI: Personal and Professional Impact; CO: Challenges and Obstacles valued both the technical skills and the broader ethical implications introduced during the course. For instance, one student highlighted: *"I deepened my knowledge of machine learning and ethical concerns in technology, which I will carry forward in my career"*.

- **Motivation and Engagement (ME)**: Motivation was another prominent theme, with 11 students mentioning increased motivation to pursue STEM fields, particularly as women in a typically male-dominated sector. Many students were inspired by the course content and the representation of women role models. For example, one student wrote: *"The course gave me the confidence and motivation to continue in the field of data science, inspired by the stories of women leaders in STEM"*.
- **Personal and Professional Impact (PPI)**: Some students (5 out of 28) mentioned the impact of the course on their personal and professional aspirations. These students reflected on how the course had shifted their perspective on technology and ethics, motivating them to pursue further education or career paths in STEM. A student stated: *"The discussions on ethics and gender representation in technology encouraged me to think more critically about the impact of my work in this field"*.
- **Challenges and Obstacles (CO)**: Some students (6 out of 28) reflected on the challenges they encountered during the course, such as the complexity of machine learning concepts and balancing time management with course assignments. Despite these difficulties, these students often viewed the challenges as growth opportunities, as seen in this comment: *"The course was challenging, but it was through this intensity that I learned to overcome obstacles and gain confidence in the tech field"*.

The sentiment of the feedback was overwhelmingly positive. An analysis of the tone and language used in the reports revealed that students expressed a high level of satisfaction with the course, frequently using terms such as "empowering", "motivating", and "inspiring". Even when challenges were mentioned, they were often framed as opportunities for growth. The combination of high satisfaction and the application of self-regulation techniques indicates that the HLJ successfully fostered academic and personal growth among its participants.

6 Discussion

This work assesses the HLJ model, a learning method encouraging young women to engage in STEM courses. Experts and students evaluate HLJ, revealing significant insights into the model's educational design and motivational effectiveness. By examining feedback from both groups, we can identify where the HLJ excels at fostering engagement and where it requires improvement.

The expert evaluations conducted during the FOSTWOM workshop provide a valuable external perspective on the design and motivational potential of the HLJ stages. Experts were tasked with assessing the motivational capacity of each stage and suggesting improvements. Their feedback indicated that all 12 stages received at least 60% positive ratings for motivational impact, suggesting that the HLJ framework is generally effective in engaging learners. In particular, Stages 1, 4, and 5 were rated especially motivating by the experts, with over 83%

agreement on their positive motivational potential. These stages align with key moments in the Heroine's Journey: the introduction to the new world of STEM (Stage 1), overcoming initial fears (Stage 4), and learning to balance challenges and strengths (Stage 5). From the students' perspective, these stages also received positive feedback, as evidenced by the quantitative ratings in the MOOC platform. Stage 1, which introduces students to the narrative and sets the tone for the entire journey, was the most highly rated, with an average rating of 4.7 out of 5. This initial stage plays a crucial role in capturing student interest and setting expectations for the course. Similarly, Stage 5, *Transforming Fear into Strength*, resonated with students, providing an empowering message and introducing female role models, a significant motivational factor for many learners. Both experts and students agreed that these stages were particularly effective in motivating learners.

However, there were differences in the evaluation stages between experts and students. Stage 6, *The Light of Knowledge*, was identified by experts as needing significant improvement, with 75% of experts agreeing that it required greater clarity and more practical application to better motivate learners. This stage, which deals with applying STEM knowledge in real-world contexts, may have been challenging for learners to engage with without a clear connection to practical experiences. Students, while not giving this stage the lowest ratings, also reflected on the content's complexity, suggesting that more concrete examples or hands-on activities might have helped bridge the gap between theoretical knowledge and practical application. Stage 9, *The STEM Badge*, was another stage where expert and student evaluations diverged slightly. Experts pointed out that this stage, while intended to motivate and reward learners for their progress, could benefit from clearer guidelines for managing pressure and building self-confidence. On the other hand, students rated this stage lower than the earlier stages, possibly due to fatigue or the natural decrease in engagement as learners progress through the course. Despite these lower ratings, the students who completed this stage expressed satisfaction with the sense of accomplishment it provided, particularly those who resonated with the message of pushing beyond their comfort zones.

One of the HLJ model's important contributions is its integration of self-regulated learning, which is central to Stage 10, *Self-Regulated Learning*. This stage was designed to align with the self-reflection phase of Zimmerman (2008) cyclical model of self-regulation, allowing students to assess their learning strategies, goal-setting, and personal growth. The qualitative feedback from students during this stage revealed that it was a pivotal moment in their learning journey, with many reporting increased self-efficacy and a deeper understanding of their learning process. The thematic analysis of the reflective reports highlighted four key themes: Skills and Knowledge Acquired (SKA), Motivation and Engagement (ME), Personal and Professional Impact (PPI), and Challenges and Obstacles (CO). Most students emphasized acquiring new skills and knowledge, particularly in technical areas such as machine learning and data ethics, which was a primary goal of the HLJ. This aligns with the experts' assessment, which also identified skill acquisition as a core strength of the HLJ framework. Additionally, students expressed high motivation and engagement, frequently citing role models and the narrative structure as key factors in sustaining their interest.

The feedback also highlighted personal and professional impacts, with students reflecting on how the course had changed their perspectives on gender representation in STEM and inspired them to pursue further studies or careers in these fields. This was particularly relevant in Stages 5 and 10, where the narrative emphasizes overcoming internal and external challenges and reflecting on personal growth. The experts also noted the importance of these stages for fostering long-term engagement with STEM subjects, suggesting that the combination of role models, narrative challenges, and self-reflection effectively supports gender equity in STEM education. The HLJ's narrative structure, divided into three acts, was consistently praised by both experts and students for its ability to sustain engagement and guide learners through increasingly complex challenges. Act I, *Empowerment*, sets the stage for building confidence. In contrast, Act II, *Growth*, focuses on skill acquisition, and Act III, *Return*, emphasizes reflection and the application of knowledge. This structure mirrors traditional heroic narratives, effectively motivating learners to persist through the course. Experts highlighted the importance of the feedback and reflection opportunities embedded in the narrative, particularly in Act III, where learners are encouraged to reflect on their journey. The students' feedback supported this, with many noting that the reflective activities in Stage 10 helped them internalize the skills they had learned and apply them to real-world contexts. This reflective component is critical to fostering self-regulated learning, as it enables students to develop strategies to overcome challenges in their future STEM education and careers.

The combined evaluations from experts and students underscore the effectiveness of the HLJ model in promoting motivation, engagement, and self-regulation among learners. While both groups identified areas for improvement, particularly in clarity and practical application in certain stages, the overall feedback suggests that the HLJ's narrative approach, combined with opportunities for reflection and feedback, is a powerful tool for supporting gender equity in STEM education. The integration of self-regulated learning in Stage 10, in particular, was a key factor in helping students reflect on their progress and prepare for future academic and professional challenges.

7 Conclusion

Evaluating the 12 stages of the HLJ has been important for validating the model's effectiveness in motivating young women to engage in STEM fields. Both expert evaluations and student feedback provide strong evidence of the HLJ's impact on student engagement, learning outcomes, and personal development. The inclusion of gender representation and ethical concerns, along with the narrative structure, has proven to be particularly powerful in enhancing motivation and persistence, especially in traditionally male-dominated STEM subjects. The expert panel, comprising 12 specialists in Massive Open Online Courses (MOOCs) and educators, provided valuable insights into the motivational potential at each stage. These evaluations highlighted the strengths of the HLJ model, particularly its ability to sustain student engagement through key narrative moments. Stages such as Stage 1 (*Learning Heroine's World*) and Stage 5 (*Transforming Fear into Strength*) were consistently rated as highly motivational by both experts and students, emphasizing the effectiveness of starting the course with an empowering narrative and maintaining momentum through overcoming challenges. However, experts identified areas for improvement, particularly in stages requiring clearer practical application of concepts, such as Stage 6 (*The Light of Knowledge*), which addresses abstract STEM knowledge. In parallel, student evaluations echoed similar sentiments, with high ratings for the earlier stages, particularly Stage 1, which had an average rating of 4.7 out of 5. The inclusion of strong female figures in the course was well-received by students, and the narrative approach helped sustain their interest. To further enhance the motivational impact of role models in Portuguese-speaking countries and Latin America, we will incorporate brief biographies of influential women in STEM from these regions. Qualitative feedback from Stage 10 (*Self-Regulated Learning*) was particularly revealing, showing how the students internalized the lessons learned throughout the journey. This stage, aligned with Barry Zimmerman's cyclical model of self-regulation, encouraged students to reflect on their learning strategies and personal growth. Students reported increased self-efficacy and confidence, particularly when confronted with complex STEM challenges such as machine learning and ethical data handling.

Furthermore, two key awards, the SBC Innovation Seal and the SIGHP Education Award, recognize the HLJ's innovative contribution to STEM education. The SBC Innovation Seal acknowledges the HLJ's success in promoting gender equity in STEM, particularly its narrative approach and use of real-world role models. Meanwhile, the SIGHP Education Award highlights the global impact of the HLJ, specifically recognizing its ability to inspire and motivate young women through digital platforms and MOOCs, reinforcing its role in breaking down barriers in STEM education. These accolades further validate the model's scalability and its potential for broader societal change, which emphasizes the HLJ's alignment with Sustainable Development Goals (SDGs) 4 (Quality Education) and 5 (Gender Equality). Incorporating these new evaluations and accolades reinforces the HLJ's dual contribution: first, as a framework to engage and inspire young women in STEM, and second, as an adaptable model for other educational contexts. The expert evaluations have validated the HLJ's motivational potential and provided a roadmap for improving certain stages by integrating more practical examples and real-world applications, as noted in Stage 6. These insights can be applied to refine the model and increase its relevance globally in STEM education.

Future research will expand the HLJ by integrating AI and digital literacy, aligning it with UNESCO's Competency Framework for Students (CFS) to promote ethical AI use in K-12 education. This integration will enhance the HLJ's 12 stages with CFS competencies, fostering responsible digital citizenship and addressing gender disparities in STEM. Scalability will be explored through diverse educational settings, with longitudinal studies assessing its long-term impact on career choices and STEM engagement. Expanding the participant pool across cultural and socioeconomic backgrounds will refine its adaptability. Recognized for promoting gender equality in STEM, the HLJ will continue evolving with emerging technologies while maintaining its core mission of empowering young women through narrative education.

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