The Redesign of a Master's Course for Technology Teacher Students to Better Foster Research-Inquiry Attitudes

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Abstract

In this article, we document a framework for developing recommendations to improve a master's course for technology student teachers to better foster research-inquiry attitudes. A French case study of seven years of the master's teacher education course is analysed. The study adopted a three-phase educational design research model: analysis and exploration, design and construction, and evaluation and reflection. The data consists of 54 master theses (2014-2021), the degree coursework documentation, and teacher-educators notes. In the end, a discussion is proposed on the practices implemented in the teacher education master's degree course oriented to research-inquiry attitude and recommendations for potential enhancements to technology teacher education.

Keywords: teacher education, master thesis, teacher learning, research inquiry attitude

Introduction

The COVID-19 pandemic has reinforced the crucial role of learning design, indicating the need to re-think lesson design to ensure innovative engagement in an increasingly globalized context. The pandemic has also reminded us of teachers' need to update their competencies and pedagogies to meet 21st-century challenges (Caena & Redecker, 2019).

Master's degree programs vary significantly internationally, as do the expectations of those who undertake them. However, many master's degrees in teacher education stress the role of developing research skills, focusing on and culminating in a master's thesis. Considering this, there is a gap in the literature on models to support teacher-educators in designing master's degree courses in technology education (Niiranen, 2021). In the broader framework of the professionalization of teacher education and the integration of research in teacher training, this paper aims to highlight the influence of research inquiry attitudes on technology teacher education (Brisco & Bang, 2021). The research-inquiry attitude refers here to the attitudes of technology student teachers toward research that can improve and affect reflective processes about the teacher's role. Our research intent is to document the redesign of a master's degree

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course to foster the research-inquiry attitudes of its students better. A case study of a seven-year-old French master's degree course is analyzed to answer this question. The article summarises reflections on practices implemented for the teacher education master's degree course and makes recommendations for potential enhancements to technology teacher education.

Learning Design in French Technology Teacher Education

Technology education has its roots in craft, vocational, and science education (de Vries, 2018) and has evolved to now help future citizens understand, critically reflect, and creatively influence the technological world (Ge et al., 2015) by developing technological literacy (O'Toole & Kelestyn, 2021). In achieving these goals, the teacher's role is to direct pupils through an open-ended problem-solving and design process, promoting knowledge-building and competency development by using technology as a tool for creativity and innovation.

Since 2013, to become a recognised teacher in all levels of French public schools, a master's degree is required, called "*Métiers de l'enseignement, de l'éducation et de la formation*" (MEEF). It is provided by the School of Education (*Higher Schools of Teaching and Education*) as a prerequisite for teaching (Ministry of National Education and Youth, MEN, 2013).

At the national level, the MEEF master's degree program is based on Education Ministry teacher standards (MEN, 2013) that are "a professional skills framework that defines the objectives and the culture common to all teaching and education professionals." The teacher standards elicit three main objectives: (a) to affirm that all staff work towards common objectives and can refer to the common culture of their profession; (b) to recognize the specificity of teaching and education professions in their context of practice, identify the expected professional skills; and (c) to acquire the skills from initial training and continue development throughout their career through professional experience and the contribution of continuing training.

The MEEF master's program for technology teacher education is related to the didactics of the discipline: implementation of lessons in technology, cultural and scientific specificities, and a transversal unit to generate a reflexive approach with analysis of situations and commitment to a research process resulting in the production of the thesis. This transversal unit is designed for both primary and secondary levels, and also for the different subject orientations of student teachers.

This two-year teacher education MEEF master's degree is based on theoretical and practical experiences. It enables student-teachers to build competencies related to the knowledge taught in the range of curriculum units. The rationale for the master's degree qualification is not to strictly apply scientific research but to prepare the student teachers to deal with various authentic and practice-oriented issues with a positive research-inquiry attitude. The master's degree program requires full-time enrolment, with mandatory

courses at the School of Education and mandatory stages in the school level selected (maternal, primary, middle, and higher school).

Specifically, in the first year of the master's degree, practical experience in a school is based on observation, aimed at developing skills for a first professional simulation. These goals are achieved in close collaboration with the teaching staff of the School of Education and under the guided supervision of the schoolteacher in charge. These master's students, referred to here as student teachers, must actively participate in the organization of teaching sequences, considering the respective subject areas.

In the second year of the master's degree, the student teachers who have passed the national examination have the status of official part-time teachers and can teach lessons in a classroom. In this different status, the teacher participates in all activities concerning the life of the school in terms of teaching (preparing lessons, assessments, etc.), academic support, and institutional involvement (participation in school projects, etc.).

The version of the two-year master's degree program described in this article was updated in September 2022. For the 2022-2023 academic year, the national exam was moved to the end of the master's degree and no longer between the first and second year of the master's degree program. In this way, students have more time for didactic and pedagogical preparation. Furthermore, in the first year, they are involved in developing a master's thesis based on a professional situation to be investigated with scientific and educational research. Different courses are provided about educational research and methodologies. The thesis is oriented to reflect the path of the student teachers, linking theoretical issues to professional experiences. The thesis is concluded and officially presented at the end of the second year as the final requirement to complete the master's degree program.

The Master's Thesis for Reflective Practice and Research-Inquiry Attitude

The introduction of the master's thesis, as a device to focus the study of the production of knowledge, is embedded broadly in many teacher education curricula worldwide. The main objective of the thesis is to produce generalizable knowledge for the specific field of study through scientific research through immersion in a professional problematizing paradigm related to observed modalities and practices to enrich the field.

Developing an attitude toward research skills during teacher education can enhance critical thinking and the implications of technology and science in society through the process of articulating knowledge (Joliat & Arcidiacono, 2020). Along with the reflection, the research and writing process involved in the master's thesis encourages authors to learn more about themselves as a by-product and consequently strengthen their professional identity. Indeed, the thesis contributes to developing reflective practices as one of the competencies

required to be a good teacher, as discussed in the educational literature about teacher professional development (Avalos, 2011).

In addition, the School of Education is currently engaged in developing structures to support a research-inquiry attitude in teacher education. In addition to contributing generalizable knowledge in the field, teachers can be consumers of research, interpreting the findings of others and applying them in the classes they teach. Developing a sound and meaningful research proposal in the master's course is, for many, their first actual contact with research.

In the French technology teacher master's program, the assessment of the thesis is done with a competencies approach, so it considers: a critique of relevant literature; appropriate data collection tools; analysis of data; presentation and reporting; writing, referencing, and formatting standards; developing a reflective posture; evidence of a technological vocabulary; inclusion of research papers and websites in a foreign language; and integration of the elements of the digital culture necessary for contemporary teaching professionals.

The Conceptual Framework Adopted

The conceptual framework for this study (Table 1) is informed by Paavola and Hakkarainen's (2021) critical principles for learning design. The six principles of their trialogical learning approach guide the analysis and the planning of teaching and learning activities. The main characteristics of these principles focus on the mediation process, knowledge of artifacts, knowledge practices, and object-oriented activities. It is called "trialogical" because it integrates the "monological" approach to learning, centered on the processes of individual and conceptual knowledge, and the "dialogical" approach, based on distributed cognition, the role of social and material interactions, with the intentional processes involved in collaboratively producing artifacts of knowledge that are shared and useful for the community. Paavola and Hakkarainen explain that "collaboration is not only a matter of sharing meaning and understanding but involves shared efforts of advancing envisioned epistemic objects (e.g., artifacts and practices) that are given tangible (i.e., materially embodied) form in terms of writing, visualization, prototyping, or other means" (p. 243). The model is influenced by knowledge-building theory (Bereiter & Scardamalia, 2003) based on collaborative learning and aimed to sustain students in creating knowledge artifacts. The model is supported in the literature (Lakkala et al., 2012; Rugelj & Zapušek, 2018) and related to engineering, technology, and digital skills (Engeness, 2021). As indicators to evaluate impact, the framework focuses on the main aspects that teacher-educators could consider for successful learning design. The six principles guide the teachers into the learning design that valorises the collaborative creation of knowledge, which is produced at all levels of participation in a process of sharing and collaboration, which aims to grow both the individual and the community.

Table 1
Critical Principles for Learning Design

Six Principles	Definitions
Organizing activities around shared "objects"	The activities are organized around shared objects (also intended as practices and processes). These are recognized as essential and intended for actual use beyond the individual and social dimensions of learning.
Supporting interaction between personal and social levels	The interaction between the personal and social levels must be supported: it is necessary to arouse individual and collective initiative, combining individual work with group work. So, there is a combination of individual work with that collaborative work as complementary.
Fostering long-term processes of knowledge advancement	Long-term processes of knowledge advancement must be promoted. This principle is implemented both retrospectively, using previous skills and knowledge, and prospectively, thinking about how the built objects will evolve later. There is an iterative inquiry cycle in a supportive environment, including creative reuse of previous practice and knowledge artifacts.
Emphasizing development through transformation and reflection between forms of knowledge and practices	Knowledge develops through the transformation from one format to another (for example, from a theoretical format to a more practical one or from a textual format to a concept map). There is so the activation of various declarative, procedural, and implicit forms of knowledge and practices.
Cross-fertilization of various knowledge practices across communities and institutions	It is important to create connections with other contexts with which to interact and make use of the built object. This explicitly combines the practices and the languages of different contexts.
Providing flexible tool mediation	Provide adequate and diversified technologies to mediate collaborative activities.

Note. Adapted from "*Trialogical Learning and Object-oriented Collaboration,"* by S. Paavola and K. Hakkarainen, 2021 in *International Handbook of Computer-Supported Collaborative Learning* (pp. 241-259), Springer, Cham.

The Case Study

Research Questions

The study was exploratory as it aimed to examine the development and implementation of the learning design of a master's course in teacher education that would foster student teachers' research-inquiry attitudes. The following research question guided the study: How can a teacher education master's degree course be redesigned to better foster research-inquiry attitudes?

Context and Participants

The master's course for technology teacher students that was analysed has been offered by a university School of Education in France for seven years. The two-semester thesis course was in the second year of the master's degree program. The course started in September with theoretical and methodological lessons about research in educational science. It ended in May with the presentation and oral discussion of the thesis with a jury. Throughout the two semesters, students familiarised themselves with the reading of scientific literature, methodological research procedures, tools and solutions for data collection and analysis, and the writing process to finalise the master thesis.

The target group was students in the second year of the master's degree program. As stated, the students sat a national examination between the first and the second year of the master's degree program, which qualified them to enter the teaching profession. So, in the second year of the master's degree program, they had the status of half-time teachers in the classroom at high schools in the region. Considering their double status as part-time students and teachers, collecting data for their master's thesis was done in their local school, where they performed their first professional experiences.

The course accommodated an average of 25 students each year. The participants were men and a minority of women for each cohort (80% men and 20% women). The age range was 25 to 45 years. Many students, such as design engineers, were from industry and realized they needed a career change. The participants generally did not have advanced academic writing skills, considering their backgrounds and interests, but most shared an interest in technology. The student teachers were teaching half-time in a vocational high school in applied arts, mechanical engineering, vocational education, or industrial engineering departments. All the data were anonymized, fully respecting the ethical protocols.

The students worked in pairs to develop a master's thesis, a document between 30 and 50 pages that included an introduction, methodology, data collection and analysis, and results. The topic was selected with the explicit invitation to solve a professional field problem in their practice and to make it possible to propose courses of action to solve the problem. The research inquiry was based partly on the theoretical contributions of various resource disciplines (psychology of learning, didactics, sociology, etc.) to understand what is

happening in the classroom, enabling the student teacher to reflect deeply on their current practice.

Since the introduction of the master's course, three teacher-educators have been involved in the two-semester course: one man and one woman with more than twenty years of experience and one woman with less than five years of experience. The same team was active throughout the course's seven-year history. The teacher-educator's role was to solicit the identification of professional issues, link this to a research topic, and guide students toward producing the master's thesis.

Research Design and Methods

This study adopted a three-phase educational design research model. As illustrated by McKeeney & Reeves (2013), the three interconnected phases were: (a) analysis and exploration, (b) design and construction, and (c) evaluation and reflection. These phases were iterative and flexible, influencing the ongoing processes and ultimate outputs.

The design research study was coordinated by one internal teacher-educator (this article's first author) involved in all the course editions. The analysis was performed with the support of the second author external to the School of Education. This strategy was proposed to help maintain objectivity and disclose a potential bias in the analysis process.

The data collected throughout the three-phase research included:

- 54 master theses (2014-2021),
- the degree coursework over the seven years,
- the student teachers' notes in Moodle and in shared online spaces, and
- the three teacher-educators' observations and reflective notes.

As a preliminary stage, we conducted a literature review to gain theoretical input on designing and improving master thesis courses in teacher education. In this phase, the six principles outlined by Paavola and Hakkarainen (2021) were considered. We also discussed with teacher-educators the issues in the master's degree program. Then an exploration took place where we gathered all the material that would be used in the analysis. To collect empirical data for the evaluation of the course, different sources were employed, namely reflective diaries of teacher-educators, students' final theses and reported written and oral suggestions about the course, and a Moodle space and a google drive space that collected the teachers' and students' documentation shared and produced in each year's edition.

For the first "analysis and exploration" phase, we performed an analysis of the master's thesis collection (2014-2021) to gain knowledge about the technology teacher course in the last seven years. The data consisted of 54 theses in total. The thesis collection data was reported in Microsoft Excel and organized into the main features: year, title, keywords, abstract, and conclusions.

After cleaning the dataset, the title and keywords were subject to content analysis to identify the main topics. We analysed the data using qualitative inductive content analysis (Mayring, 2014). Based on multiple readings of these materials, we identified segments that contained meaningful units and created a label for each category to which the text segment was assigned. We organised the theses into five categories and each title was assigned to only one category. The abstract and conclusions were subjected to a word frequency analysis to identify and rank the research design used.

For the second "design and construction" phase, we assessed the current edition of the master course (2021-2022) through the critical design principles (Paavola & Hakkarainen, 2021) to determine the strengths and weaknesses of the learning design course from a research-inquiry perspective. We analysed the data using qualitative thematic analysis, looking at: the conceptual framework of the degree coursework; posts and notes in Moodle and shared workspaces; and three teacher-educators' observations and reflective notes.

During the final "evaluation and reflection" phase, recommendations for future implementation of the course learning design (2022-2023) were discussed, then, followed by a "rise above" reflection, which aimed to help refine our theoretical understanding of the learning design.

Results

First Phase Results: Analysis of the Master Thesis Collection

The results of analyzing the titles and keywords of 54 master theses are presented in Table 2. The most common topic to emerge was motivation and engagement in a task. These inquiries were directed toward pedagogical aspects, like maintaining students' interest with an active and appropriate learning design. A second major area of research was the heterogeneity of communication and collaborative learning, for example, related to teacher-student relationships and active pedagogies to foster motivation and attention. A third major topic was the role of digital tools such as iPads, robotics (in 2 cases), video, and specific software for quick evaluation, such as online quizzes. The students were interested in digital tools as a support for active learning (for example, in the title of one thesis, "*Role of the digital tablet in student and teacher interaction*").

Table 3 presents the word frequencies that emerged from the analysis of the abstracts and conclusions of theses. The word frequency has only the limited goal of acknowledging the most common research processes. The primary data collection processes used in the master's theses were observation with a codebook in the classroom, student survey, and experimental tasks designed to collect data.

This first "analysis and exploration" phase gave us an overview of the student teachers' theses, providing information about the course over the last

seven years. In conclusion from this first step of the analysis, we noticed how the master theses cover pedagogical and educational topics which are not uniquely technology education related. This could be related to the need to bridge the gap between and consolidate their subject expertise and the pedagogical and educational practices.

Table 2
Five Categories Emerging from the 54 Thesis Titles

Topic	n
Motivation & engagement in tasks	17
Heterogeneity, communication, & collaborative learning	16
Learning design with digital tools	10
Content & knowledge retention	7
Evaluation for learning	4
Total	54

Table 3
Results of Word Frequency in the Abstract and Conclusions

Rank	Word	Frequency
1	Learning	1251
2	Observation	1121
3	Professional	1016
4	Group	914
5	Evaluation	910
6	Knowledge	766
7	Competence	761
8	Motivation	731
9	Teacher	679
10	High school	641
11	Survey	634
12	Content	627
13	Experimental task	455

Second Phase: Assessment of the Current Edition of the Master Course

The 2021-2022 edition of the technology course was analyzed considering the critical learning design principles derived from Paavola and Hakkarainen (2021). The principles suggested which dimensions to stress to reshape the course's current version toward a more explicit and positive research-inquiry attitude. This analysis is represented in Table 4.

Relative to the first principle, *organizing activities around shared "objects,"* teacher-educators noted at the start of the course, that many students expressed concerns about the difficulties in finalising the thesis. This initial resistance to the thesis activity was expected because students had not yet developed sufficient writing and reading skills and habits related to scientific and educational literature. For this reason, teacher-educators offered reassurances that the course would build the skills students needed to succeed in their thesis. The thesis was a confusing output at the beginning of the course. To help shape students' conceptions, relevant examples of master's theses were given by offering access to an open repository of theses.

With the goal of *supporting interaction between personal and social levels*, the second principle, teacher-educators challenged pairs of students to produce a thesis; working together student pairs selected the topic, decided and performed the collection and analysis of the data, and collaboratively wrote the thesis. The "research buddy" introduced critical dialogical and reflective dimensions and co-responsibilities in the production. Sometimes, tensions developed within the pairs of students, and the advantages of working together were reinforced and verbalized. The research design protocol took a long time to be defined, and it was the source of animated discussions before moving from the "my" to "our" perspectives. The teacher-educators were called to mediate possible conflicts that could compromise the quality of the final thesis.

The third design principle, *the long-term fostering processes of knowledge advancement about attitudes toward research inquiry,* was embedded in the research process but only sometimes explained to the students. Consequently, it needed to be clarified to them. For example, the research methodologies may have been appropriate to answer their research question, but master's students did not consider these tools and methods to be relevant for their future work. To address this issue, teacher-educators invited former master's students into the classroom to describe their experiences and make suggestions for managing the thesis process. The visit from former students had a reassuring effect, thanks to the tips on how to better plan and deal with both the thesis work and teaching in their own classrooms. Also, former students gave a long-term projection of how the competencies developed during the course would be useful in future professional work.

The fourth design principle, *the transformation and reflection of forms of knowledge and practices,* was solicited through the requirement that student teachers give presentations in different modalities. Teacher-educators supported

Table 4
Design Principles Applied to the Technology Master's Course

Design Principle	Application to the Course
Organizing activities around shared "objects"	The course was oriented toward producing the master thesis. Pedagogical resources were shared in the progression of the research plan (literature review, research questions, hypothesis, results, etc.).
Supporting interaction between personal and social levels	The students worked in a pair. Students were free to develop two case studies with the same theoretical and methodological sections or a joint case study. The case question was identified based on concrete and contingent professional difficulties.
Fostering long-term processes of knowledge advancement	The course was offered during the second year of the master's degree program. The research progress was discussed collectively in the classroom group. The peer discussion in the classroom was regular, along with the teacher-educator support.
Emphasizing development through transformation and reflection between forms of knowledge and practices	The students were invited to read scientific papers to find the main perspectives on the topic selected. News of seminary and research activities in the research laboratory and the education school was shared. Periodical presentations with a video, in a poster format, or as an oral pitch were done by each group.
Cross-fertilization of various knowledge practices across communities and institutions	Their professional subject reframed the research topic. The school-based teacher supported the student teacher's research process during the course. The mentoring schoolteacher was invited to join the master jury.
Providing flexible tool mediation	Different digital space was provided as mediation: online space like Google Drive was used for sharing live changes in the works; the learning management "Moodle" was the institutional platform to deposit the resources and shared documentation; and email was the primary tool to share with the teacher students for personalised requests.

this multimodal approach by providing templates and methodologies for transforming knowledge. Practitioner journals were proposed, along with videos, links, and support for exploring and overcoming difficulties in reading scientific papers. The peer collaboration was central to supporting the research and writing process.

Analysing the course through the lens of the fifth design principle revealed a weakness related to the *cross-fertilization of various knowledge practices across communities and institutions*. Indeed, the students rarely involved other stakeholders—colleagues, senior teachers, students' parents, or other institutions—in their research inquiry. The school-based teacher supported the student-teachers in the classroom for their professional activities but was not involved in the research inquiry. This showed a weak link between research done in the school of education and teaching practices. To facilitate integration, teacher-educators invited the school-based mentors to join the final jury committee.

Finally, regarding the last principle—*providing flexible tool mediation*, a variety of supports were intentionally proposed to boost the student's confidence in the use of interactive tools and to support exchanges within the students' community. Supports included Google Drive for sharing files, "Moodle", a learning management system, and email. The use of the hybrid modality was more frequent, especially during and after COVID-19 with the use of video conference tools such as Zoom.

With an aim to address students' needs and improve teaching modalities, the teacher-educators solicited student reflections and recommendations regarding the flexibility to adopt or abandon digital tools. For example, toward the end of a unit in a Google Drive file called "Suggestions and Improvements," one student reported his self-awareness about the modality of learning:

> *In the beginning, face-to-face is essential to be guided by the team on the orientation's choices. The readings and constitution of the reading sheets are rather personal and do not necessarily require group work. It isn't easy to come to the School of Education and concentrate on doing this work. When developing the research question, the hypothesis, and the design of the data collection, I think it is essential to be face-to-face in a group to really be able to bring out all the ideas and discuss them freely. For the drafting and analysis of the results, remote work is mainly feasible. The group communicates quickly with interfaces such as Microsoft Team, where all the work is shared and updated automatically on all the computers simultaneously*.

Third Phase: Develop Recommendations for Future Editions of the Course

In light of the two preliminary phases of the three-phase educational design research model, the third step was designed to develop recommendations for the future of the course.

In the first stage, the overall vision of the thesis indicated the interests and attitudes of research inquiry by the technology student teachers. The first phase analysis confirmed that students appropriate the theoretical and methodological contents for the research inquiry applied in the thesis, such as identifying features of social research and how to write an abstract and research questions. In addition, this analysis revealed that past theses were focused mainly on pedagogical topics that were not always technology oriented.

In the second phase, the master's course was analysed through the lens of six design principles (Paavola & Hakkarainen, 2021). The results stressed features that could be valorised, such as the cross-fertilization of various knowledge practices across communities and institutions and the role of collaboration in knowledge advancement.

The following six recommendations emerged and were shared with the teacher-educators and mentors community involved in the learning design:

1. Propose an initial template/tutorial document with the main characteristics of the course explained to counter the "fear" of the thesis, with suggestions about how to involve the other stakeholders.
2. Plan regular group discussions about challenges experienced during the course, such as the appropriation of theoretical readings. This will help to support interpersonal boundaries and social confrontations within the group. It is also helpful to sustain peer assessment during the writing process.
3. The design of the master's course is a critical point of co-appropriation of positive research-attitude development. A more articulated orchestration for sequencing the activities, learning objects, and tools of different actors—researchers, teachers, students, parents, experts, etc.—is necessary. This will require preliminary coordination work by the teacher-educators and mentors who are involved in the learning design.
4. Clarify with concrete examples the possible uses of the research competencies and reflective practices acquired during the course and the thesis production into teaching activities, such as how to read a scientific paper and find valuable resources. This could be especially relevant during the initial stage of professional development so that student teachers can envision the long-term benefits of inquiry-related approaches and be receptive to continuing involvement in research.
5. Involve stakeholders in writing and reading with the invitation of mentoring schoolteachers. Tentative reframing of the selected topic from an interdisciplinary perspective must be supported.
6. Let the students self-organize as much as possible with various digital tools. Valorise the specific genre of the research writing process as a

specific literacy oriented to their research attitude and reflection engagement.

We consider that these recommendations support and can broaden the research-inquiry attitude inside the master's degree program. The broader vision may help students to position themselves in a more critical position and to project the application of a research-inquiry attitude across contexts and situations. Also, the recommendations stress the role of social support, such as co-planning by multidisciplinary teams, which increases future teachers' versatility and success in implementing technology education (Aarnio et al., 2021).

Conclusion

This article aimed to identify specific features which can develop the research-inquiry attitude of technology education master's students in producing a master's thesis and proposed recommendations for the redesign of the course.

The thesis emerged as a "boundary object" (Star & Griesemer, 1989) that connected the teacher-educators' work, the institutional demand of the master's requirement, and the professional context. As a boundary object, the thesis was flexible enough to adapt to the personal needs and constraints of the educational and professional stakeholders, yet robust enough to maintain a common identity across contexts. This specific function of the master's thesis has to be stressed throughout the master's course to emphasize better the implications of the thesis process to promote critical and reflexive practices.

The teacher-educators' and mentors' roles were central to eliciting the reflexive practices necessary for the student-teacher's induction and projection into the role of a teacher, but this was inadequately discussed and meta-analysed with the students inside the course. This study suggests that teacher-educators may assist student teachers in appropriating a positive research-inquiry attitude by more deliberatively negotiating the learning design principles in their course and by demonstrating the value of the thesis relative to students' entry into the teacher role. This could lead to a critical, self-reflexive, lifelong practice for technology teachers.

Regarding the methodology, the design-based research approach helped the teacher-educators involved in the learning design of the master's course to shape and reframe the learning occurring in the course in light of the collected experiences.

Further possibilities to develop the learning design will be explored through the open approach of the Virtual Exchange (O'Dowd, 2021.). The adaptation of the Virtual Exchange in the light of the model proposed will be explored for transnational collaboration and international teacher-educators involved in technology teacher education.

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