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Assisting Instructors in the Design and Provision of Personalised LA-informed Feedback in MOOCs

Presentada por

Paraskevi Topali

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Dirigida por
Alejandra Martínez-Monés
Sara Villagrá-Sobrino
Alejandro Ortega-Arranz

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Presented by

Paraskevi Topali

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Advisors
Alejandra Martínez-Monés
Sara Villagrá-Sobrino
Alejandro Ortega-Arranz

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To my family
Sakis, Stella, Stefanos

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Abstract

Massive Open Online Courses (MOOCs) have gained increasing prominence in the educational landscape over the last decade due to the lifelong learning opportunities they offer. Despite their benefits (e.g., free access to education), providing timely and personalised feedback (often associated with learner disengagement) is still viewed as an important challenge due to the high number of students enrolled in these courses. The field of Learning Analytics (LA) provides opportunities for scaling up the feedback interventions, monitoring the learners' progress, and enabling automatic or semi-automatic interventions. However, current LA solutions often lack pedagogical underpinning from theory and consideration of the course particularities. Additionally, there may be a mismatch between instructors' needs and the provided LA information. Building on this context, the current dissertation aims to assist instructors in the design and delivery of personalised LA-informed feedback in MOOC environments. Following a Design-Based Research methodological approach, the current dissertation proposes three research objectives.

The first research objective deals with understanding the current state of instructor-led LA-informed feedback in MOOCs. Accordingly, a systematic literature review was conducted within the context of the current dissertation. The evidence gathered revealed that the LA tools proposed to assist instructor-led feedback in MOOCs often lack course contextualisation, pedagogical grounding, and user guidance in the process of designing and/or interpreting the information provided by the LA tool.

The second research objective delves into the need of helping MOOC instructors to shape personalised and contextualised feedback. In response to this need, this dissertation proposes a conceptual framework named FeeD4Mi. FeeD4Mi defines 5 dimensions for the design of feedback, accompanied by a process, a set of catalogues (for potential learners' problems, potential LA-based indicators to identify such problems, and potential feedback reactions), and a set of recommendations to guide MOOC instructors in the design of the LA-informed feedback interventions.

The third research objective aims at providing a manageable design and provision of personalised and contextualised feedback strategies in MOOCs. To this end, this dissertation proposes a set of design guidelines that permit the incorporation of FeeD4Mi into technological tools. This way, the computer-interpretable representation of the feedback strategies and their automatic or semi-automatic implementation is enabled. These guidelines led to the

creation of e-FeeD4Mi, a tool that permits MOOC instructors to use FeeD4Mi digitally in practice.

The research process followed a human-centred approach, positioning the MOOC instructors actively in the design and refinement of the suggested proposals. Four evaluative studies with MOOC instructors served for an iterative FeeD4Mi enhancement and assessment. The results indicated the added value of the framework (both in digital and paper-based version) to support the design and provision of instructor-led LA-informed feedback in MOOCs and to automate their feedback strategies. The evaluation outcomes led to further research directions of feedback in MOOCs which are also discussed. The application of FeeD4Mi for other educational contexts different than MOOCs, such as blended learning, or the extension of FeeD4Mi catalogues with higher level indicators, such as "*low student engagement"* or "*low collaboration*".

Keywords

MOOC, Feedback, Struggling Learners, Learning Analytics, Human-Centred Design, Systematic Literature Review, Conceptual Model, FeeD4Mi, e-FeeD4Mi.

Resumen

Los cursos masivos abiertos en línea (MOOC por sus siglas en inglés) han recibido una gran atención en el panorama educativo en las últimas décadas gracias a las oportunidades de aprendizaje continuo que ofrecen. A pesar de tales beneficios educativos, la provisión de retroalimentación (feedback en inglés) personalizada y en un tiempo adecuado es uno de esos desafíos, a menudo asociado con la pérdida de interés de los estudiantes. El campo de las Analíticas de Aprendizaje (LA por sus siglas en inglés) brinda oportunidades para ampliar las intervenciones de retroalimentación mediante herramientas que monitorizan el progreso de los estudiantes, y permiten intervenciones automáticas o semiautomáticas. Sin embargo, las soluciones actuales de Analíticas de Aprendizaje a menudo carecen de una base pedagógica y de la consideración de las particularidades del curso. Además, existe una discrepancia entre las necesidades de los instructores y la información de LA proporcionada. De acuerdo con este contexto, esta Tesis Doctoral tiene como objetivo ayudar a los instructores en el diseño y la provisión de retroalimentación personalizada basada en Analíticas de Aprendizaje en entornos MOOC. Siguiendo un enfoque metodológico de Investigación Basada en Diseño, esta tesis aborda tres objetivos de investigación.

El primer objetivo de investigación trata de comprender cuál es el estado actual del uso de feedback informado por Analíticas de Aprendizaje dirigida por un instructor en los MOOC. En consecuencia, se realizó una revisión sistemática de la literatura. Los resultados obtenidos de Analíticas de Aprendizaje revisadas muestran la falta de consideración de aspectos contextuales específicos del curso, base pedagógica y orientación al profesorado en el proceso de diseño y/o interpretación de la información proporcionada por estas herramientas.

El segundo objetivo de investigación aborda la necesidad de ayudar al profesorado de MOOC en el diseño de feedback personalizado y contextualizado. Atendiendo a esta necesidad, esta Tesis Doctoral propone un marco conceptual denominado FeeD4Mi. FeeD4Mi consiste en una estructura conceptual de 5 dimensiones, acompañada de un proceso, un conjunto de catálogos (formado por potenciales problemas que pueden experimentar los estudiantes, indicadores para identificar los problemas y un conjunto de reacciones para abordarlos), y un conjunto de recomendaciones para guiar al profesorado en el diseño de retroalimentación informada por Analíticas de Aprendizaje en cursos MOOC.

El tercer objetivo de investigación pretende facilitar el diseño y puesta en marcha del uso de feedback basado en Analíticas de Aprendizaje en MOOC. Para ello, esta tesis propone un conjunto de guías de diseño para incorporar FeeD4Mi en unas herramientas web. De esta manera se ha profundizado en la representación digital de estrategias de retroalimentación para MOOC facilitando su implementación automática o semiautomática. Los principios de diseño emanados de esta tesis doctoral han conducido a la creación de e-FeeD4Mi, una herramienta que permite a los instructores de MOOC poner FeeD4Mi en práctica.

El proceso de investigación siguió un enfoque centrado en el ser humano, involucrando a los instructores de MOOC activamente en el diseño y perfeccionamiento de las propuestas sugeridas. Cuatro estudios evaluativos con la participación de los instructores de MOOC sirvieron para refinar y evaluar iterativamente FeeD4Mi. Los resultados indicaron el valor añadido del marco (tanto en su versión en papel como digital) para apoyar el diseño y la provisión de comentarios informados por analítica de aprendizaje dirigidos por instructores en MOOCs y en la automatización de sus estrategias de comentarios. Finalmente, los resultados apuntan hacia nuevas direcciones de investigación en el área de la retroalimentación en MOOCs. Por ejemplo, la aplicación de FeeD4Mi para contextos educativos distintos a los MOOC, como el aprendizaje blended, o la ampliación de los catálogos de FeeD4Mi con indicadores de alto nivel como "*bajo compromiso del estudiante*" o "*baja colaboración*".

Palabras clave

MOOC, Retroalimentación, Estudiantes en Apuros, Analíticas de Aprendizaje, Enfoque Centrado en el Ser Humano, Revisión Sistemática de Literatura, Modelo Conceptual, FeeD4Mi, e-FeeD4Mi.

Περίληψη

Τα Μαζικά Ανοιχτά Διαδικτυακά Μαθήματα (MOOC σύμφωνα με τα αρχικά τους στα Αγγλικά) έχουν συγκεντρώσει ιδιαίτερο ενδιαφέρον στο εκπαιδευτικό τοπίο την τελευταία δεκαετία χάρη, στις ευκαιρίες δια βίου μάθησης που προσφέρουν. Παρά τα εκπαιδευτικά τους οφέλη, τα MOOC εξακολουθούν να συνοδεύονται από πολλές προκλήσεις που έχουν αντίκτυπο στη μαθησιακή εμπειρία. Για παράδειγμα, η παροχή έγκαιρης και εξατομικευμένης ανατροφοδότησης αποτελεί μια διαρκής πρόκληση, που συχνά συνδέεται με την απώλεια ενδιαφέροντος των χρηστών κατά τη διάρκεια του μαθήματος. Το πεδίο των Learning Analytics (LA) παρέχει ευκαιρίες για αυτοματοποιημένες ή ημιαυτόματες παρεμβάσεις, με εργαλεία που παρακολουθούν την πρόοδο και την αλληλεπίδραση των μαθητών με την πλατφόρμα MOOC. Ωστόσο, οι τρέχουσες λύσεις LA συχνά στερούνται παιδαγωγικής βάσης και δεν λαμβάνουν υπόψιν τις ιδιαιτερότητες του μαθήματος. Επιπλέον, υπάρχει αναντιστοιχία μεταξύ των αναγκών των καθηγητών και των παρεχόμενων πληροφοριών βάσει των LA. Η τρέχουσα διατριβή στοχεύει να βοηθήσει τους καθηγητές στο σχεδιασμό και την παράδοση εξατομικευμένης ανατροφοδότησης βάσει των LA σε περιβάλλοντα MOOC. Για την επίτευξη αυτού του στόχου, η παρούσα διατριβή προτείνει τρεις ερευνητικούς στόχους ακολουθώντας την μεθοδολογική προσέγγιση της Έρευνας Βασισμένης στο Σχεδιασμό.

Ο πρώτος ερευνητικός στόχος ασχολείται με την κατανόηση των τεχνολογικών προτάσεων και εργαλείων που υποστηρίζουν τους καθηγητές στην παροχή ανατροφοδότησης βάσει των LA στα MOOC. Κατά συνέπεια, πραγματοποιήσαμε μια συστηματική ανασκόπηση της βιβλιογραφίας. Τα αποτελέσματα κατέδειξαν την έλλειψη παιδαγωγικής θεμελίωσης των εργαλείων LA για τη διαμόρφωση της ανατροφοδότησης και την έλλειψη καθοδήγησης στους καθηγητές για τον καλύτερο σχεδιασμό των στρατηγικών ανατροφοδότησης.

Ο δεύτερος ερευνητικός στόχος εμβαθύνει στην ανάγκη να βοηθήσουμε τους καθηγητές να διαμορφώσουν εξατομικευμένη ανατροφοδότησης στα MOOC. Ως αποτέλεσμα, η παρούσα διατριβή προτείνει ένα εννοιολογικό πλαίσιο, το FeeD4Mi. Το FeeD4Mi απαρτίζεται από 5 διαστάσεις, μια κατευθυντήρια διαδικασία, ένα σύνολο καταλόγων (για πιθανά προβλήματα μαθητών, πιθανούς δείκτες δεδομένων για τον εντοπισμό τέτοιων προβλημάτων και πιθανές ιδέες ανατροφοδότησης) και ένα σύνολο προτάσεων που λειτουργούν ως «καλές πρακτικές».

Ο τρίτος ερευνητικός στόχος στοχεύει στην εξασφάλιση της διαχειρισιμότητας του σχεδιασμού ανατροφοδότησης για MOOCs. Για το

σκοπό αυτό, η παρούσα διατριβή προτείνει ένα σύνολο οδηγιών για την ενσωμάτωση του εννοιολογικού πλαισίου σε τεχνολογικά εργαλεία. Με αυτόν τον τρόπο, επιτρέπεται η αυτόματη ή ημιαυτόματη εφαρμογή της ανατροφοδότησης που προκύπτει χάρη στο FeeD4Mi. Αυτές οι οδηγίες οδήγησαν στη δημιουργία του e-FeeD4Mi, ενός εργαλείου που επιτρέπει στους καθηγητές των MOOC να χρησιμοποιούν ψηφιακά το FeeD4Mi στην πράξη.

Κατά τη διατριβή ακολουθήθηκε μια ανθρωποκεντρική προσέγγιση, με τη συμμετοχή καθηγητών MOOC τόσο στον εντοπισμό των ερευνητικών προβλημάτων όσο και στο σχεδιασμό και τη βελτίωση των προτεινόμενων προτάσεων. Συνολικά, τέσσερις μελέτες αξιολόγησης διενεργήθηκαν εξετάζοντας την χρησιμότητα του εννοιολογικού πλαισίου. Τα αποτελέσματα αναδεικνύουν την προστιθέμενη αξία του πλαισίου (τόσο σε έντυπη όσο και σε ψηφιακή έκδοση) στους καθηγητές για τον σχεδιασμό, την παροχή και την αυτοματοποίηση της ανατροφοδότησης βάσει των LA στα MOOC. Τα αποτελέσματα της αξιολόγησης επισήμαναν, επίσης, περαιτέρω ερευνητικές κατευθύνσεις που θα μπορούσαν να διερευνηθούν δυνητικά στο μέλλον. Για παράδειγμα η χρήσης του πλαισίου FeeD4Mi στην τριτοβάθμια εκπαίδευση και η επέκταση των καταλόγων με δείκτες υψηλότερου επιπέδου, όπως "*το χαμηλό επίπεδο του ενδιαφέροντος των μαθητών*" ή "*το χαμηλό επίπεδο συνεργασίας*".

Λέξεις Κλειδιά

MOOC, Ανατροφοδότηση, Learning Analytics, Ανθρωποκεντρικός Σχεδιασμός, Συστηματική Ανασκόπηση Βιβλιογραφίας, Εννοιολογικό Πλαίσιο, FeeD4Mi, e-FeeD4Mi.

Contents

Introduction 1

1.1. Motivation 1

1.2. Dissertation goals and contributions 5

1.3. Research Methodology 9

1.4. Structure of the dissertation 15

Theoretical Background: Feedback in MOOCs 17

2.1. Introduction 17

2.2. Delving into MOOCs 20

2.3. Benefits and Challenges of MOOCs 22

2.4. Feedback in Education 24

2.4.1. Introducing Feedback 24

2.4.2. Main Feedback Models and Recommendations 25

2.5. Feedback in MOOCs 30

2.6. Conclusions 33

Exploring the Learners' & Instructors' Constrains in MOOCs 35

3.1. Introduction 36

3.2. Exploratory Studies with MOOC Learners 38

3.2.1. Overview of the First Exploratory Study [Exp_1] 39

3.2.2. Overview of the Second Exploratory Study [Exp_2] 40

3.2.3. Results of the Exploratory Studies [Exp_1] & [Exp_2] 41

3.3. Exploratory Study with MOOC Instructors 46

3.3.1. Overview of the Third Exploratory Study [Exp_3] 47

3.3.2. Results of the Exploratory Study [Exp_3] 48

3.4. Discussion 51

3.5. Conclusions 53

LA-Informed Feedback In MOOCs: A Systematic Literature Review 55
4.1. Introduction 56
4.2. Research Questions 59
4.3. Methodology 60
4.4. Results 62
4.4.1. RQ1: Publications' Information 63
4.4.2. RQ2: Feedback Design Aspects 64
4.4.3. RQ3: Implementation of the Proposed Intervention 67
4.4.4. RQ4: Feedback Effects 70
4.5. Discussion 71
4.6. Conclusions 74

FeeD4Mi: The 'Feedback Design for MOOC Instructors' Framework 77
5.1. Introduction 79
5.2. Related Work 81
5.3. FeeD4Mi: The 'Feedback Design for MOOC Instructors' Framework. 83
5.3.1. FeeD4Mi Dimensions 83
5.3.2. FeeD4Mi Process 85
5.3.3. FeeD4Mi Catalogues 89
5.3.4. FeeD4Mi Recommendations 94
5.4. Scenario of FeeD4Mi Application 95
5.5. FeeD4Mi Design Guidelines 98
5.6. Conclusions 105

FeeD4Mi Evaluation 107
6.1. Introduction 108
6.2. Evaluative Studies 110
6.2.1. First Evaluative Study [EV_1] 110
6.2.2. Second Evaluation Study [EV_2] 112
6.2.3. Third Evaluation Study [EV_3] 114

6.2.4. Fourth Evaluation Study [EV_4] 116
6.3. Methodology 117
6.4. Results 120
6.4.1. Results: Catalogue Completeness 120
Evaluative Study 1 [EV_1] 121
Evaluative Study 2 [EV_2] 121
Evaluative Study 3 [EV_3] 122
Evaluative Study 4 [EV_4] 123
6.4.2. Results: FeeD4Mi Usefulness (Catalogues, Process, Recommendations) 124
Catalogue Usefulness 125
Process Usefulness 131
Recommendations Usefulness 133
6.4.3. Results: Feedback Impact on Instructors and Learners 134
6.4.4. Results: Perceived Workload 136
6.4.5. Results: Perceived Usability 137
6.5. Discussion 140
6.6. Conclusions 145

Conclusions and Future Work 147
7.1. Conclusions 147
7.2. Limitations 151
7.3. Future Lines of Work 152
7.3.1. Potential Research Expansions 153
7.3.2. Prospective Application of Proposals in TEL 155
7.4. Publications and Research Projects 156
7.4.1. Publications 156
7.4.2. Research Projects 158

Appendix A: Εκτενης Περιληψη Διατριβης 161
Appendix B: Systematic Literature Review Papers 185

Appendix C: FeeD4Mi Catalogues.....189
Appendix D: Evaluation Questionnaires 193
Appendix E: Abbreviations.....203

Bibliography.....205

List of Figures

Figure 1.1 General dissertation schema including the context, research question, objectives, contributions, and evaluation studies. 6

Figure 1.2 Design-Based Research methodological approach (Amiel & Reeves, 2008) 11

Figure 1.3. Designed-Based Research methodological approach followed during this dissertation 12

Figure 2.1. Research context of this dissertation 19

Figure 2.2. Timeline of MOOCs and Open Education (Yuan & Powell, 2018) 21

Figure 2.3. Growth of MOOCs by numbers (Shah, 2021) 22

Figure 3.1. Overview of the exploratory studies addressed in Chapter 3 and their association with the contribution. 37

Figure 3.2. Behavioural analysis boxplot comparison between cohorts of participants based on their experiences towards solving problems. 44

Figure 3.3. (A) Z-test (2-tailed) p-values and (B) mean values of the variables measuring behavioural engagement for the different cohorts according to who the students asked for help. 44

Figure 3.4. Boxplot comparison between the participants who reported they put less effort (Avoid Effort) and the ones put their maximum effort (Max Effort) before asking for support 45

Figure 3.5. Representation of the activity sequence of a MOOC learner within a three-day period. 46

Figure 3.6. Participants' profiling information related to the gender, role, MOOC experience in terms of delivered courses and country. Figure retrieved from Topali et al. (2020). 48

Figure 3.7. Learners' problems as reported by the interviewees with experience in MOOCs of Social Sciences & Humanities, of Computer Science & Engineering and with experience in both fields. Figure retrieved from Topali et al. (2020) 49

Figure 3.8. Challenges of MOOC instructors. Figure is adapted from Topali et al. (2020) 51

Figure 4.1. Overview of the process of instructor-led LA-informed feedback in MOOCs. 57

Figure 4.2. Overview of the objective and contribution addressed in Chapter 4. 58

Figure 4.3. Anticipatory data reduction schema including the RQs, the four sub-questions (circles) and informative questions (rectangles) guiding the systematic literature review. 60

Figure 4.4. Overview of the systematic literature review process followed..... 62

Figure 4.5. Left: Publications attending to the year of publication and publication type. Right: Publications attending to the year of publication and contribution type. 63

Figure 4.6. Purposes of LA-informed feedback in MOOCs. 66

Figure 4.7. Distribution of the studies over the five thematic areas. See Paper ID in Appendix B.1. 67

Figure 4.8. Relationship between the LA techniques applied and/or proposed and the feedback purposes. 69

Figure 5.1. Overview of the research objectives and contributions addressed in Chapter 5. 80

Figure 5.2. Graphical representation of the FeeD4Mi conceptual framework, that briefly depicts the process and the examples of the catalogue suggestions. 85

Figure 5.3. Illustration of the FeeD4Mi process. 89

Figure 5.4. Example scenario of the FeeD4Mi process application. The case of Sophie. 97

Figure 5.5. The FeeD4Mi process applied in a paper-based approach..... 99

Figure 5.6. e-FeeD4Mi screenshot highlighting the progress bar of the user within FeeD4Mi process. 100

Figure 5.7. Top: Paper-based version of outlining the course LD following FeeD4Mi. Bottom: Digital version of LD representation LD following FeeD4Mi. 101

Figure 5.8. Consideration of indicators in e-FeeD4Mi. Top: selection of self-reported indicators. Bottom: selection of monitored-based indicators. 102

Figure 5.9. Configuration of the intervention timing (see yellow frame) in e-FeeD4Mi. 103

Figure 5.10. Representation of the catalogues and recommendations in e-Feed4Mi. Top: Potential learners' problems related to regulation issues. Bottom: Recommended indicators. 104

Figure 5.11. Example of additional aspects (e.g., potential problems) that can be inserted by instructors. 104

Figure 5.12. Hints and explanations to facilitate the independent use of FeeD4Mi in e-FeeD4Mi. 105

Figure 6.1. Overview of the studies involved in the evaluation of FeeD4Mi.... 109

Figure 6.2. MOOC participants applying FeeD4Mi during the evaluation study. Left: Case#A, face-to-face. Right: Case#B, online. 111

Figure 6.3. Screenshot of the FeeD4Mi process during [EV_2]..... 113

Figure 6.4. Feedback designs created following the FeeD4Mi process in [EV_3]. 115

Figure 6.5. Screenshot of the [EV_4], during which a MOOC instructor while creating feedback designs with e-FeeD4Mi. 117

Figure 6.6. Topics addresses by the four evaluation studies..... 118

Figure 6.7. Informative Questions addressed in this dissertation related to the objectives 2 & 3..... 119

Figure 6.8. Connections among the data gathering techniques and the evaluative studies. 120

List of Tables

Table 1.1. Main data gathering techniques employed during the four DBR cycles. 15

Table 2.1. Summary of the presented feedback models. 28

Table 3.1. Data sources applied in [Exp_1]. 39

Table 3.2. Data sources applied in [Exp_2]. 40

Table 3.3. Selected excerpts of evidence [Exp_1]. 42

Table 3.4. Selected excerpts of evidence [Exp_3]. 49

Table 4.1. Decisions taken during the systematic literature review planning phase. 60

Table 4.2. Summary of the log data reported in the reviewed papers. See Paper ID in Appendix B.1. 68

Table 5.1. Catalogue of Learners' Problems 90

Table 5.2. Catalogue of Problem Indicators 91

Table 5.3. Catalogue of Feedback Reactions. 93

Table 5.4. Recommendation of feedback strategies under concrete learner problems 94

Table 5.5. Summary of the design guidelines created to apply FeeD4Mi into tools 99

Table 6.1. Catalogue completeness during the four evaluation studies. 121

Table 6.2. Excerpts of evidence associated with catalogue completeness in [EV_4] 124

Table 6.3. Learner Problems retrieved by FeeD4Mi during the three evaluation studies. 125

Table 6.4. Indicators retrieved by FeeD4Mi during the three evaluation studies associated with learners' problems. 126

Table 6.5. Feedback reactions retrieved by FeeD4Mi during the two evaluation studies. 128

Table 6.6. Excerpts related with the usefulness of the FeeD4Mi catalogues. .. 129

Table 6.7. Excerpts of evidence related with catalogue limitations 130

Table 6.8. Excerpts related with the FeeD4Mi process as examined during the evaluation studies..... 131

Table 6.9. Excerpts of evidence related to the difficulties faced during the evaluation studies..... 132

Table 6.10. Excerpts of evidence related to recommendations' usefulness in [EV_4]..... 133

Table 6.11. Excerpts related with the impact of the feedback strategies..... 134

Table 6.12. Excerpts of evidence regarding the impact of FeeD4Mi framework to MOOC instructor. 135

Table 6.13. Time spent during each FeeD4Mi phase of the process in the evaluation studies..... 136

Table 6.14. Excerpts of evidence related with the perceived workload..... 137

Table 6.15. Excerpts of evidence regarding the usability of e-FeeD4Mi to MOOC instructors 138

Table 6.16. Excerpts of evidence about the potential adoption of the feedback decisions in [EV_4]. 139

Table 6.17. Excerpts of evidence related to the e-FeeD4Mi enhancements proposed in [EV_4]. 139

Chapter one

INTRODUCTION

Summary: This chapter describes the **general research context** of the dissertation, the research questions, the objectives, and the methodology followed to accomplish such objectives. The dissertation focuses on **instructor-led personalised feedback in MOOCs**. Concretely, we intend to support instructors in the design and provision of personalised feedback interventions informed by Learning Analytics. Following a **Design-Based Research** methodological approach, we propose **two contributions** aiming to overcome current drawbacks in MOOCs. First, we aim to **understand and extend the current body** of research on Learning Analytics tools for providing instructor-led feedback in MOOCs, uncovering the challenges and limitations associated with the topic. Second, we aim to provide instructors with **a conceptual framework** to design and provide personalised feedback in such massive environments. Throughout the research process we employed a **human-centred approach** involving MOOC instructors both in the identification of the research problems, and in the design and refinement of the suggested contributions.

1.1. Motivation

The continuous change and improvement of technology impacts every aspect of our daily life in the way we act, work, and communicate. In education sector, the field of **Technology-Enhanced Learning** (TEL) aims to support the enrichment of learning experiences and teaching practices through the application of Information and Communication Technologies (ICTs), through computer-based learning and online educational opportunities (Kirkwood & Price, 2014). The technological development and the shift of the traditional learning models (e.g., face-to-face learning) led to the open education movement and the adoption of distance learning strategies (Yang & Kinshuk, 2016), among which we find the so-called "**Massive Open Online Courses" (MOOCs)** (Siemens, 2013).

Siemens (2013) describes MOOCs as a midpoint of learning and teaching between the conventional classroom environments and the open and distributed information encountered in the web. MOOCs scale distance learning and promote educational equity, providing free-access opportunities devoid of geographical and cost constrains (Ferguson & Sharples, 2014; Kumar & Brahmbhatt, 2018; Siemens, 2013). That is, MOOC learners have access to structured and high-quality learning resources created by prestigious institutions at their own pace and time. Additionally, these courses enable the connection of individuals with other people from different backgrounds around the world. At the same time, MOOC instructors can expand their teaching practices to digital and massive settings and gain professional visibility. Given the remote learning experience they offer, the COVID-19 pandemic outbreak fostered the global adoption and application of MOOCs at all educational levels (Chen et al., 2020; Ma & Rindlisbacher, 2020). The growing importance of MOOCs can be showcased by the fact that higher education institutions started to credit online Bachelor and Master degrees based on MOOCs (Ledwon & Ma, 2022; Shah, 2021). Nonetheless, while MOOCs have been efficient in attracting learners, the courses have been criticized for their high rates of learner disengagement and abandonment, and the low pedagogical and instructional design quality (Aldowah, Al-Samarraie, Alzahrani, & Alalwan, 2020; Ferguson & Sharples, 2014). Given this context, **feedback**, a cornerstone of learning and pedagogical design, can help to overcome the aforementioned limitations (Gregori, Zhang, Galván-Fernández, & Fernández-Navarro, 2018; Zhu, Bonk, & Sari, 2018). Previous studies associated the absence of timely and personalised feedback according to learners' needs as one of the causes for the high course disengagement in MOOCs (Aldowah et al., 2020; Gregori et al., 2018; Khalil & Ebner, 2014).

Hattie & Timperley (2007, p. 81) define feedback as "*the information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding*". Feedback is essential during the learning process (Sawyer, 2006) with benefits for both feedback agents i.e., feedback provider and feedback receiver. The feedback information helps the instructors to enhance their teaching practices and the learners to improve their performance and to develop capacities, such as self-regulation skills (Molloy & Boud, 2014). The authors conceptualize the purpose of feedback as mitigating the inconsistency between the actual and the desired state of the learners' performance or understanding (Hattie & Timperley, 2007). Given its purpose, feedback supports opportunities of personalised learning, i.e., learning tailored to individuals aptitude (Maier & Klotz, 2022). To do so, the feedback provider has to be aware of the learners' progress by collecting evidence from various sources and to deliver the most adequate interventions

according to their learners' behaviours and needs (van de Pol, Volman, & Beishuizen, 2010; Wood, Wood, Ainsworth, & O'Malley, 1995). While traditional learning settings (e.g., face-to-face courses) enable teachers to be aware of learners progress and needs in real time, MOOC settings hinder the awareness and feedback provision, due to their massive, diverse and online character (Khalil & Ebner, 2014).

The provision of timely and personalised feedback is among the main challenges to MOOC instructors (Pappano, 2012; Sari, Bonk, & Zhu, 2020) and an ongoing issue rather overlooked (Estrada-Molina & Fuentes-Cancell, 2022; Gregori et al., 2018). Normally, discussion forums represent the main space where the learners communicate their problems and receive feedback (Almatrafi, Johri, & Rangwala, 2018; Onah, Sinclair, & Boyatt, 2014b). Yet, the use of forums as the primary means for assisting learners comes along with several limitations. First, discussion forums do not represent an effective solution for the provision of scalable feedback interventions. Large number of posts in forums can turn cognitively and timely unmanageable for instructors to be aware on time of learners who are struggling[1]. Indeed, questions in MOOC forums can be easily overlooked and remain unanswered or answered late and/or inefficiently (Almatrafi et al., 2018). Second, learners' participation in discussion forums is limited (<10% of the learner population) (Onah et al., 2014b; Wise & Cui, 2018), so not all learners in need of help use discussion forums to share their problems. Apart from self-reporting their problems and, thus, receiving feedback, another way commonly applied to receive feedback in MOOCs regards the automated feedback through graded assignments. Nevertheless, this type of feedback, while its timely, lacks personalisation and elaboration based on learners' needs and doubts (Vinker & Rubinstein, 2022).

The use of **Learning Analytics** (LA) can be considered as an approach to scale the provision of personalised and timely feedback in MOOCs. LA is defined as the "*measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs*" (Long & Siemens, 2011, p. 34). In other words, LA is based on the analysis of the learners' digital footprints generated when using TEL environments that nowadays are widely available, due to the increasing digitalization of education. The field of LA aims at monitoring learners' behaviour, thus providing useful information for

[1]In this dissertation we define as "struggling learners" the learners who have a certain level of activity during the course and then tend to disengage after having problems completing certain deliverables of the course (e.g., passing a test, submitting a paper) for reasons that can vary (e.g., not understanding the course concepts, not knowing how to apply them, not being able to communicate their ideas well).

identifying cohorts of learners and personalising their feedback interventions. In the case of MOOCs, research on LA has mostly focused on two aspects: (a) LA dashboards and (b) predictive models. On one hand, the LA dashboards serve to increase learners' awareness about their own learning and self-regulation (Arnold & Pistilli, 2012). Also, dashboards can strengthen the teaching practices by facilitating instructors to take LA-informed decisions to improve learning and "close the feedback loop" (Clow, 2012; Gašević, Dawson, & Siemens, 2015). On the other hand, the predictive models support, among others, the identification of specific cohorts of learners at risk of dropout, and thus instructors can shape proactive feedback interventions (Bouzayane & Saad, 2017; Halawa, Greene, & Mitchell, 2014; Xing, Chen, Stein, & Marcinkowski, 2016; Yang, Sinha, Adamson, & Rose, 2013).

However, as observed in the literature, appropriate and meaningful LA-informed feedback interventions require a **pedagogical underpinning from theory** (Jivet, Scheffel, Drachsler, & Specht, 2017; Matcha, Uzir, Gasevic, & Pardo, 2020; Papamitsiou, Giannakos, & Ochoa, 2020) and **course contextualisation** (Liu, Bartimote-Aufflick, Pardo, & Bridgeman, 2017; Shibani, Knight, & Shum, 2019). Additionally, instructors' capabilities (e.g., easiness to employ LA-generated information) should be considered in the design of LA tools (Chatti et al., 2020). Nevertheless, usually instructors lack of background knowledge and/or there is a mismatch between the instructors' actual needs and the information provided by LA tools (Fernández-Nieto, Buckingham Shum, & Martínez-Maldonado, 2022; Rienties, Herodotou, Olney, Schencks, & Boroowa, 2018).

Previous research pointed out to the joint use of LA with the course **Learning Design** (LD), thus informing and contextualising pedagogically the decisions taken based on LA (e.g., the provision of personalised feedback) (Hernández-Leo, Martinez-Maldonado, Pardo, Muñoz-Cristóbal, & Rodríguez-Triana, 2019; Lockyer, Heathcote, & Dawson, 2013; Rodríguez-Triana, Martínez-Monés, Asensio-Pérez, & Dimitriadis, 2015). Mor & Craft described LD as the "*the act of devising new practices, plans of activity, resources and tools aimed at achieving particular educational aims in a given situation"* informed by *"subject knowledge, pedagogical theory, technological know-how and practical experience*" (2012, p. 86). Rodríguez-Triana et al. (2018) suggested that the involvement of the teachers, as the course experts, could permit more informed LD decisions (i.e., instructional design decisions regarding course aspects under a pedagogical scenario). In the same research line of involving stakeholders in the design and/or development of LA tools, Shum, Ferguson, & Martinez-Maldonado (2019) conceptualized the term **"Human-Centred LA"** (HCLA) that considers processes that, among others, position actively the

stakeholders in the co-design and/or co-creation of LA tools, including those related to feedback processes. In MOOCs such involvement could regard the course instructors[2], who are the ones knowing the difficulty of each activity, the prior knowledge necessary to understand the course material, etc. Nevertheless, MOOC instructors usually have many responsibilities in designing and managing the course (Zheng, Wisniewski, Rosson, & Carroll, 2016). As a result, their involvement in the design of personalised and contextualised feedback might be time consuming and cognitively costly for them.

The current dissertation focuses on instructor-led feedback, i.e., feedback designed and provided by the MOOC instructors as experts of their courses. The abovementioned discussion opens a variety of issues and challenges related to instructor-led feedback in MOOCs and how to warrant (a) **scalable interventions**, (b) **tailored to learners' behaviours**, that are (c) **contextualised under the course learning design,** (d) **grounded on pedagogical theories** and that (e) **do not overwhelm** the instructors.

1.2. Dissertation goals and contributions

This dissertation deals with the following research question:

How to support instructors in the design and provision of personalised LA-informed feedback in MOOCs?

To address the research question, we have defined three partial objectives that tackle the challenges mentioned above. The research objectives emerged iteratively from the literature (see Chapter 2) and our own exploratory studies (see Chapter 3). In this section we describe the three research objectives and the derived contributions in their final version. The research question, the partial objectives and the contributions are depicted in Figure 1.1.

[2] We refer for simplicity to '*course instructors*', while we acknowledge that in the MOOC contexts many different roles may oversee the course design and the provision of feedback, such as instructional designers and/or teaching assistants.

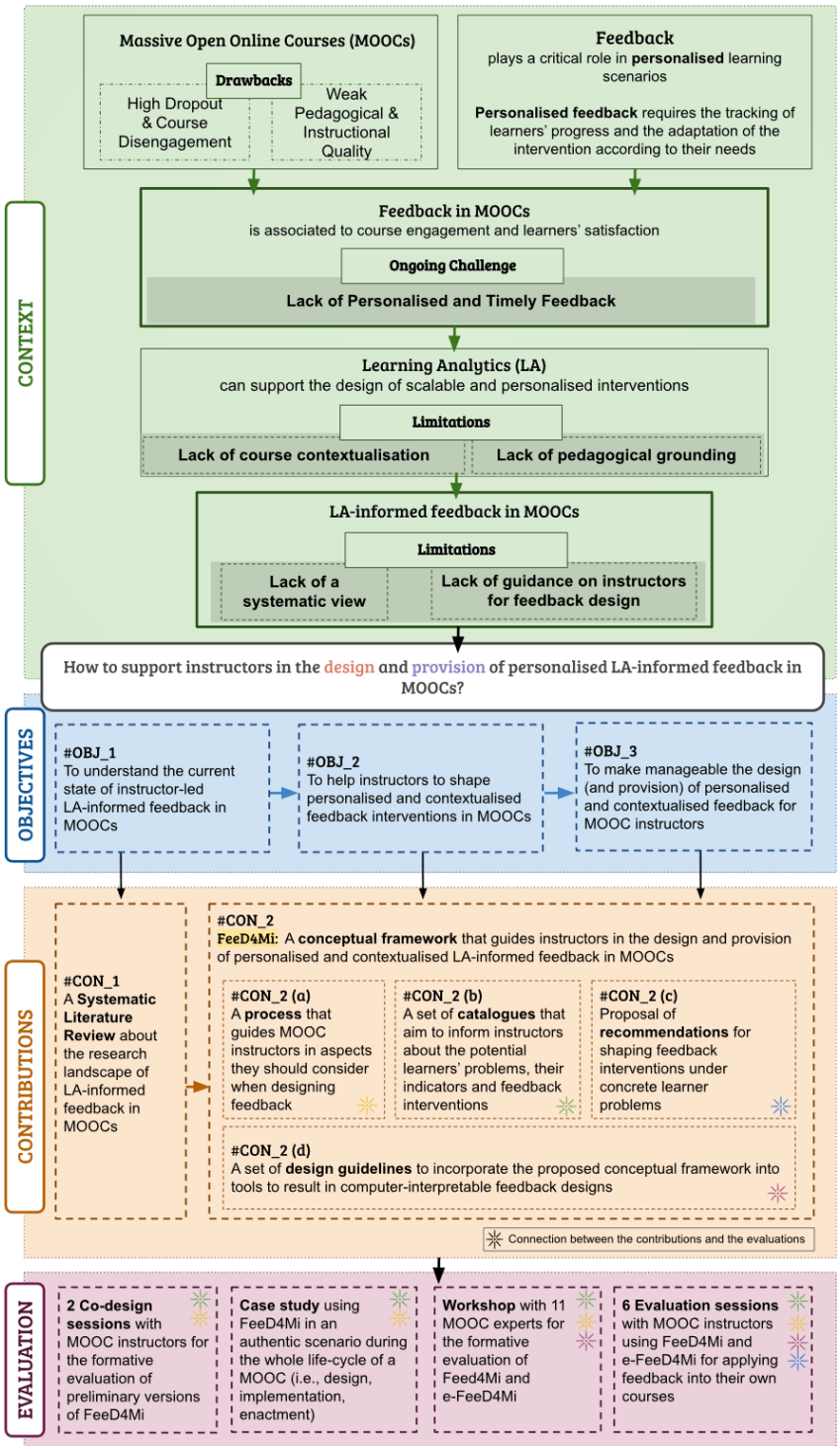


Figure 1.1 General dissertation schema including the context, research question, objectives, contributions, and evaluation studies.

#OBJ_1. To understand the current state of instructor-led LA-informed feedback in MOOCs.

As stated above, one way to face the challenges of delivering personalised and timely feedback in MOOCs is the use of LA tools that scale up feedback interventions, thus assisting the feedback providers (in our case the MOOC instructors) to shape interventions tailored to learners' needs. To understand the impact of the LA-informed feedback in MOOCs, it is relevant to know the possibilities that the current proposals offer, whether they are pedagogically grounded and whether they consider the learning context expressed through the LD. Several systematic literature reviews discuss the potential of LA for feedback in higher and online learning settings (Avella, Kebritchi, Nunn, & Kanai, 2016; Cavalcanti et al., 2021; Chiappe & Rodríguez, 2017; Lim, Gasevic, Matcha, Ahmad Uzir, & Dawson, 2021; Mangaroska & Giannakos, 2019; Schwendimann et al., 2017; Sunar, Abdullah, White, & Davis, 2016). Nevertheless, there is a lack of systematic literature reviews about the use of LA tools and frameworks for designing and automating instructor-led feedback. Consecutively, to address this objective we deem as essential to carry out ***a systematic literature review on the state-of-the-art of instructor-led LA-informed feedback in MOOCs.*** This systematic literature review is the first thesis contribution (#CON_1) and aims to uncover the way LA-informed feedback is provided in MOOCs, its extent, and its impact.

#OBJ_2. To help instructors to shape personalised and contextualised feedback interventions in MOOCs.

The second research objective intends to face the limitations described in Section 1.1 that lead to the need of supporting instructors in the design and provision of personalised LA-informed feedback in MOOCs. Previous works proposed LA models and frameworks to automate the provision of personalised feedback with the active involvement of human agents in its design (i.e., LIME, OnTask, SRES, MOOClet framework) (Burgos & Corbí, 2014; Liu et al., 2017; Pardo et al., 2018; Reza, Kim, Bhattacharjee, Rafferty, & Williams, 2021). These proposals build rule-based feedback according to the learners' behaviours during the course enactment. Nevertheless, to the best of our knowledge, these proposals do not guide instructors in the process of reflecting on feedback-related aspects (e.g., feedback type, feedback timing). Additionally, they do not support MOOC instructors in the interpretation and selection of the LA indicators. Finally, the definition of the conditions in the rule-based decisions does not take into account elements of the course design (e.g., assignment difficulty, the compulsory/optional tasks).

Therefore, to address #OBJ_2, we propose ***a conceptual framework for the design and provision of LA-based feedback interventions*** (#CON_2).

Within the framework we suggest ***a process for guiding instructors in the factors they should reflect on when designing feedback*** (#CON_2(a)). Additionally, we suggest a ***set of catalogues with information about problems, indicators, and types of feedback reactions*** (#CON_2(b)) to facilitate MOOC instructors when reflecting and designing personalised feedback interventions. Finally, we propose ***a set of recommendations of indicators and feedback reactions,*** that may serve in shaping more targeted feedback interventions (#CON_2(c)).

To do so, we aim first at identifying what are the frequent learners' problems in MOOCs that may require instructors' intervention to prevent learners' disengagement and dropout. Once having these problems, we intend to support MOOC instructors a) to identify what indicators, given the learners' behaviour, can help in detecting learners facing those problems and b) to reflect and select feedback interventions to address such learners' problems. In this process we take into consideration the involvement of instructors as the main actors to establish the parameters and thresholds for the detection of struggling learners and the delivery of personalised feedback, accordingly.

#OBJ_3 To make manageable the design (and provision) of feedback for MOOC instructors.

Throughout the iterative research methodological approach followed (see Section 1.3), we found that the design of feedback and its related components imply additional work (in terms of time and effort) to the already existing responsibilities designing and launching a MOOC. This additional work may eventually hinder the use of feedback strategies in their courses. Therefore, we considered it necessary to provide automatic or semi-automatic support for instructors, so that their interventions can be scaled up in a manageable way. To attain this objective, the proposed contribution regards ***a set of design principles to incorporate the proposed conceptual framework into technological tools to make the process more manageable for MOOC instructors and to support computer-interpretable feedback designs***.

The thesis contributions and sub-contributions have informed each other. That is, the use of the framework catalogues (#CON_2(b)) indicated the need of recommendations (#CON_2(d)), so the framework can support better MOOC instructors in the process of feedback design. Likewise, the output of the systematic literature review (#CON_1) informed part of the framework catalogues. Apart from informing each other, the proposed contributions, although they can be used separately, are connected among them. Indeed, during the evaluative studies we combined our sub-contributions (i.e., #CON_2(a), #CON_2(b), #CON_2(c), #CON_2(d)).

1.3. Research Methodology

The selection of the personal philosophical positioning, known as "*paradigm*" (Kuhn, 1996) or "*worldview*" (Jorrín-Abellán, 2016), that regards how we perceive and study the world, is among the first considerations that a researcher should make. This consideration impacts the design research decisions, i.e., the selection of methodology and the implementation of the methods (Creswell & Poth, 2017). Creswell (2007) identified four main worldviews, differing on how they recognize the nature of reality (i.e., ontology) and the nature of knowledge (i.e., epistemology): postpositivism, social constructivism, advocacy/ participatory and pragmatism.

Given my background in Education, the way I see and comprehend the world is often more interpretative, where people construct actively their own knowledge, and thus studying a concrete situation requires the understanding of people's viewpoints (Creswell, 2007). Thus, the nature and the objectives of this research context made me lean towards the pragmatic paradigm. According to this worldview, the focus lies on the problem, choosing the methods that best fit in each moment to be able to solve it (Creswell, 2007). In our case, we deal with the problem of supporting instructors to design LA-informed feedback targeted to learners in MOOCs.

Once the worldview is concretised, it comes the need of selecting the methodology that will guide the research. The methodology connects the philosophical worldview of the researcher with the systematic application of the methods to a field of study (Hesse-Biber Nagy & Leavy, 2011). Taking as starting point the pragmatism nature and our research context (i.e., proposing contributions in the educational sphere), we studied various methodologies frequently applied in TEL, such as the Design Science Research Methodology (DSRM) (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007), the System Design Research Methodology (SDRM) (Nunamaker, Chen, & Purdin, 1990), the Case Study (Stake, 1995) and Design-Based Research (DBR) (Amiel & Reeves, 2008). Among them, we consider DBR as a methodological approach that best fits with the dissertation objectives. DBR aims to solve real-world educational problems through a close collaboration between the researchers and practitioners (Amiel & Reeves, 2008) and it is recognized as a method grounded on the pragmatic worldview (Barab & Squire, 2004; Biesta & Burbules, 2003). Pragmatism intends to connect the educational research with the educational practice (Biesta & Burbules, 2003) and DBR acts as guidance for researchers and practitioners (e.g., instructors) in their coordination and collaboration on revealing the educational problem and shaping its solution (Juuti, Lavonen, & Meisalo, 2015).

Several key aspects should characterise DBR (Amiel & Reeves, 2008; Barab & Squire, 2004; Easterday, Rees Lewis, & Gerber, 2018, 2014; Kali & Hoadley, 2020). Accordingly, the reasons that led to the selection of DBR as the most suitable methodological approach for our research are the following:

- *commitment for understanding complex real-world problems in authentic settings*. DBR studies real-world practices, situating their context and characteristics at the centre of attention (Barab & Squire, 2004). Likewise, this dissertation focuses on studying the nature of MOOCs as learning environments and on supporting instructors in the design of LA-informed feedback to provide scalable interventions. Considering that the emphasis lays on a naturalistic learning context and how to bridge research with a real-world problem, DBR fits properly with the current thesis.
- *intensive collaboration between researchers and professionals in the field of education*. DBR stresses the importance of partnership among researchers and practitioners, with the last ones to be "co-participants" of the research process (Barab & Squire, 2004). Such partnership permits an equal contribution on the areas that each stakeholder masters (i.e., research and educational context) to eventually ensure the design and delivery of practical and pedagogically informed solutions that will respond in the specific needs (Anderson & Shattuck, 2012). Hence, the use of DBR led us to follow a participatory approach through a close collaboration with MOOC instructors during various research happenings (e.g., co-design events, interviews) to understand the instructors' practical problems and to enhance the developed conceptual framework according to their needs.
- *iterative cycles of design, enactment in context, analysis, and redesign*. DBR has an essentially iterative character aiming at bridging the discrepancies among theory, design, and implementation of the solutions (Juuti et al., 2015; Kali & Hoadley, 2020). In our research context, following DBR, we iteratively refined the proposed solutions. Concretely, we run four main cycles and we conducted several iterative evaluative studies until the delivery of the final thesis contributions.

Conclusively, we consider that this dissertation and its overarching objectives comply with the abovementioned aspects, thus making DBR a suitable methodological approach to frame this work. The research process of DBR involves several design phases, from the identification of the problem to the validation of the generated theories and artefacts, and it is applied in an iterative way to refine progressively the developed solutions (see Figure 1.2). These phases are (Amiel & Reeves, 2008):

a) *Analysis of Practical Problems.* This phase regards the understanding of the context, the current practices, and the needs of the stakeholders through a close collaboration between researchers and practitioners.
b) *Development of Solutions.* The second phase delves into the design and development of the theoretical or practical solutions informed by the problems as identified at the previous phase.
c) *Iterative Cycles of Testing and Refinement of Solutions in Practice.* The third phase involves iterative cycles of application of the developed solutions and their enhancement based on the lessons learnt.
d) *Reflection to Produce "Design Principles" and Enhance Solution Implementation.* The last phase concerns the achieved outcome after the completion of a DBR cycle. Such outcome may regard either the improvement of the conceptual proposal or the design of new solutions.

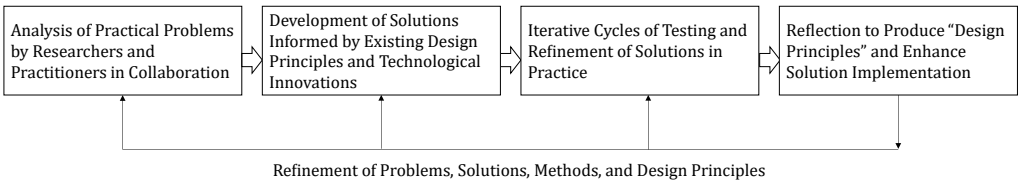


Figure 1.2 Design-Based Research methodological approach (Amiel & Reeves, 2008).

As Figure 1.3 illustrates the 4 DBR cycles carried out. During each DBR cycle and under the sphere of the pragmatic worldview, we opted for the methods that best fitted with the context and actors of the studies (Creswell, 2007). We followed a mixed method strategy (Creswell, 2014), applying both qualitative (e.g., interviews, questionnaires, content analysis of participants' artefacts) and quantitative data (e.g., log data). Additionally, we involved a variety of informants to achieve a more thorough interpretation of the findings (see Table 1.1). The four cycles are summarised below.

Cycle 1:

During the first cycle, we focused on the identification of struggling learners in MOOCs. To understand the research context, we conducted a literature review related to the problems that MOOC learners usually face at the course run-time and to how these learners can be identified. Additionally, we performed two exploratory studies in a MOOC case gathering data from learners, which informed us further about learners' problems and help-seeking strategies applied. We also performed an exploratory study, where we conducted 14 semi-structured interviews with MOOC instructors to identify their needs in the feedback provision. From the analysis emerged the need of conceptual and technological tools to support MOOC instructors in the identification of struggling learners and in the provision of tailored feedback interventions.

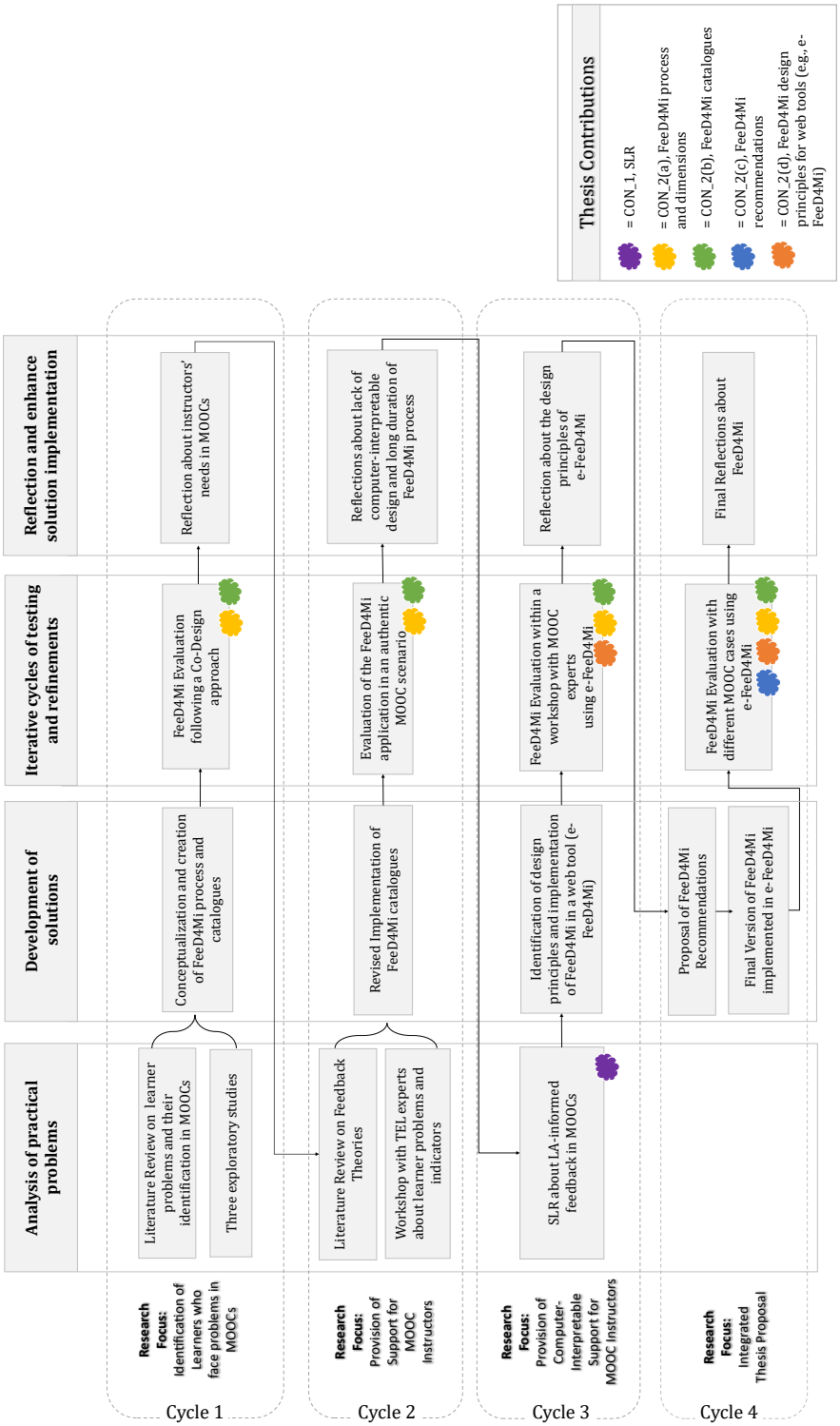


Figure 1.3. Designed-Based Research methodological approach followed during this dissertation.

Through this analysis, we generated a preliminary version of a conceptual framework, i.e., FeeD4Mi, (connected with #OBJ_2) aimed at assisting MOOC instructors in detecting and supporting learners who might face problems during course enactment. The framework contained a preliminary list of potential problems of MOOC learners and a set of indicators to detect such problems. Given the way the LD affects learners' problems, FeeD4Mi also included several aspects to be considered regarding the course design (e.g., the difficulty of the activities, the sequence among the different course resources).

Additionally, we conducted two evaluative studies to test the preliminary version of the framework with MOOC instructors considering their course contexts. During the studies we followed a participatory approach with MOOC instructors serving as co-designers of the intervention. In the last phase, we analysed the findings gathered from the studies, which guided our reflection on the topic.

Cycle 2:

In the second cycle, we put our focus on the support that MOOC instructors need for the design of feedback interventions. We reviewed the related literature on feedback theories to retrieve key aspects for successful feedback interventions as guidelines (task connected with objective #OBJ_3). The findings suggested the consideration of the four levels of feedback focus as described in the taxonomy of Hattie and Timperley (2007) (i.e., task, process, regulation and self).

The information gathered during the phase of analysis helped us complement the conceptual framework catalogues and dimensions with the introduction of aspects related to the provision of feedback (related with #CON_2(a), (b)). Accordingly, we implemented the updated version of FeeD4Mi into a complete life cycle of a MOOC, following a participatory approach with a course instructor. During this evaluative study, the instructor used FeeD4Mi in the design phase of the course to identify potential learner problems and indicators to detect them and to decide accordingly targeted feedback interventions for such problems (addressing #OBJ_2). Then, we applied the feedback decisions taken during the course enactment, so we could assess FeeD4Mi impact both on the MOOC learners and on the course instructor.

Cycle 3:

During this cycle, we put the focus on increasing the manageability of the feedback design process proposed by FeeD4Mi. To understand the current state of instructor-led LA-informed feedback in MOOCs (addressing #OBJ_1) we conducted a systematic literature review regarding tools supporting LA-based interventions (related with #CON_1) which informed us about the

number of limitations associated with current LA research about feedback in MOOCs.

In the development phase, we conceptualized a set of design guidelines for the incorporation of the framework into technological tools to automatise the process and permit the creation of computer-interpretable feedback designs (related with #CON_2(d)). Following these guidelines, we built a tool, (i.e., e-FeeD4Mi) and conducted an evaluative study to test it. This study took place in a workshop at an international conference devoted to research and practice related to MOOCs.

Cycle 4:

The findings from the evaluative study in the third DBR cycle provided insights about the requirement of additional support for MOOC instructors in terms of recommendations on concrete indicators and feedback reactions. Thus, from the literature and our previous evaluative experiences we gathered and produced a set of recommendations regarding potential indicators and feedback reactions associated to each problem included in FeeD4Mi (related with #CON_2(c)). Additionally, we refined the design guidelines related with the integration of the framework in the tool, based on the limitations reported during the evaluative study in the previous DBR cycle. During this cycle, we conducted the final evaluation study with 6 MOOC instructors, where we applied the FeeD4Mi framework to their own MOOC designs.

The above four cycles helped in the definition, the iterative refinement and evaluation of the thesis contributions. A critical aspect in a research process is the assurance of its quality and credibility. In our case, we adopted an interpretive approach and we intended to reach a deep understanding of the under-study phenomena and situations creating at the same time a dialogue with our informants. Therefore, we aimed at the transferability rather the generalisability of our results. To guarantee the credibility and transferability of our research process, we applied the following strategies (Guba, 1981; Twining, Heller, Nussbaum, & Tsai, 2017):

a) Data triangulation, i.e., using data from different participants or in different settings.
b) Method triangulation, i.e., using multiple methods to collect data and achieve the triangulation and complementation of the findings.
c) Member checking, i.e., giving participants the opportunity to comment on transcripts and emerging findings.
d) Provision of thick descriptions of the study contexts.
e) Investigators triangulation, i.e., involving two or more researchers in the data collection and/or analysis.

Table 1.1 presents the multiple data gathering techniques and sources applied during the four DBR cycles. Chapter 3, Chapter 4 and Chapter 6, present a detailed data analysis based on these techniques and sources.

Table 1.1. Main data gathering techniques employed during the four DBR cycles.

Techniques & Sources	DBR Cycle	Informants	Aim of Employing the Data Gathering Techniques & Sources
Questionnaires	1-4	Learners, Instructors, Tool Developer	-To explore learners' difficulties and reasons for dropping out . -To understand participants' perceptions about FeeD4Mi.
Activity Logs	1, 2	Learners	-To explore learners' participation and interaction in MOOCs.
Interviews	1-4	Instructors	-To analyse instructors' problems & needs -To understand instructors' impressions while using FeeD4Mi and e-FeeD4Mi.
Observations	1, 3, 4	Researcher	-To elicit participants' reflections and reactions while using FeeD4Mi and e-FeeD4Mi.
Artefacts	1-4	Instructors, learners	-To collect participants' feedback strategies about the set of the problems, indicators and feedback reactions and thus enhance and evaluate FeeD4Mi catalogues.
Recordings	1, 2, 4	Instructors	-To collect participants' comments, ideas -To collect how participants interacted with FeeD4Mi and e-FeeD4Mi,
Weekly diary	2	Instructors	-To gather instructors' weekly reflections, and strategies while using FeeD4Mi.

1.4. Structure of the dissertation

This dissertation is organised as follows:

Chapter 2 presents the theoretical background and research context of this dissertation. This chapter discusses the current state of MOOCs, its benefits and challenges associated to feedback practices. Furthermore, the chapter describes the main feedback models and key recommendations to support the quality of feedback interventions. Last, it presents the existing strategies and limitations that accompany feedback in MOOCs.

Chapter 3 provides an overview of the three exploratory studies that took place during the first DBR cycle. The studies are presented in two different sections given their different focus (i.e., the first two studies explored the learner problems during their learning in MOOCs and the third the instructor constraints to design and deliver feedback in MOOCs). The reflections derived from each of the

studies created the base for the formulation of the dissertation contributions.

Chapter 4 reports the first contribution of this dissertation (#CON_1), i.e., a systematic literature review regarding instructor-led LA-informed feedback in MOOC environments. Concretely, this chapter describes the impact and the limitations of LA-based tools aimed to deliver and/or inform instructor-led feedback interventions. Conclusions and potential implications derived from the synthesis of the results are presented at the end of the chapter.

Chapter 5 reports the second contribution of this dissertation (#CON_2), i.e., the FeeD4Mi conceptual framework, together with its components (the FeeD4Mi process, catalogues, recommendations, and the design guidelines). Additionally, the chapter offers a scenario of application of the framework.

Chapter 6 exposes the evaluation of FeeD4Mi (including its catalogues, process, recommendations, and tool design principles) according to the dissertation objectives raised in Chapter 1. The evaluation consisted of four studies, two with formative and two with summative purposes, conducted during each of the four DBR cycles. The studies output and the level of completion of this dissertation goals are discussed at the end of this chapter.

Chapter 7 draws the final conclusions of this dissertation, underlining the relevance of our work within the educational research area and TEL community. Moreover, given the findings of the conducted research, this chapter outlines: a) the implications of our work in other learning settings, b) the limitations identified during our evaluation studies, and c) future directions of research work.

Finally, this dissertation provides a set of appendices that contain supplementary material, including: an extensive summary of the dissertation in Greek (see Appendix A); the list of the papers included at the conducted systematic literature review (Appendix B); a detailed description of the FeeD4Mi catalogues of learner problems and feedback reactions (Appendix C, see C.1, C.2); the questionnaires applied during our evaluative studies (Appendix D); a list of all the acronyms, abbreviations and labels used throughout the manuscript (see Appendix E).

Chapter two

THEORETICAL BACKGROUND: FEEDBACK IN MOOCS

Summary: This chapter frames the context of this dissertation, analysing in depth the problems mentioned in the previous chapter. To begin with, the chapter provides an overview of **MOOCs**, focusing on their benefits and current limitations. MOOCs are offering numerous opportunities in online and distance learning, yet the high dropout and learner disengagement rates are among their weakest points. Previous literature connected such limitations with the one-size-fits-all instructional approach that most MOOCs follow, failing to satisfy the learners' needs and to provide personalised feedback. Next, the chapter describes the concept of **feedback** in education, presenting the main feedback models and key recommendations to ensure the quality of feedback interventions. Finally, this chapter delves into the existing strategies and limitations that accompany the design and provision of **feedback in MOOCs**. For instance, the use of **Learning Analytics** is suggested to scale the feedback interventions, however current proposals came along with several restrictions.

2.1. Introduction

Before going in detail on the research context of this dissertation, let us imagine the following scenario: building on the recent agenda of the University of Valladolid aiming at promoting online learning, Sonia, a teacher of ICT at the Department of Education, wants to launch a MOOC about teachers' digital literacy. She has prepared most of the material needed for a 5-week course with many individual and collaborative activities.

Although the course is almost ready, Sonia is concerned about how to provide personalised and timely feedback during the course run-time. During her face-to-face courses, Sonia monitors her students and provides different

types of assistance, varying from general hints to more detailed tutoring, according to their progress. However, her plans do not match with the MOOC reality and her lack of experience in online and distance learning. So, she deals with the following question: "*How can I support my MOOC learners in a personalised and scaled way? This cannot happen only via discussion forums, as I cannot follow all the posts. Does it worth the provision of personalised feedback to learners or it is enough with general messages to all students?*"

MOOCs regard a peculiar learning context, bringing many advantages both to learners and instructors. At the same time, MOOCs also imply several ongoing challenges such as the design and provision of personalised and timely feedback (Estrada-Molina & Fuentes-Cancell, 2022; Gregori et al., 2018). Attending to this issue, previous works report the use of LA, in means of dashboards (Cobos & Soberón, 2020; León-Urrutia, Cobos, & Dickens, 2018) or predictive models, (Bouzayane & Saad, 2017; Teusner, Hille, & Staubitz, 2018; Xing & Du, 2018) that, based on learners' trace data, aim at scaling the monitoring of learners' behaviour, thus, assisting instructors in the provision of timely and personalised feedback. However, the LA tools used for monitoring the learners' progress often lack pedagogical grounding and contextualisation in the course design (Avella et al., 2016; Chiappe & Rodríguez, 2017). Additionally, the course instructors often face difficulties in use, interpretation, and reflection upon the LA information (Fernández-Nieto et al., 2022; Rienties et al., 2018).

This chapter introduces the theoretical background of this thesis, and its key concepts, i.e., **MOOCs** and **feedback** (see Figure 2.1). In particular, Section 2.2 and 2.3 uncover the origins of MOOCs and the benefits and limitations that normally accompany the courses. Section 2.4 delves into the concept of 'feedback', describing its importance and impact in education in general. Section 2.5 discusses the current strategies on feedback in MOOCs and the solutions proposed to support scaled interventions (i.e., **the use of LA tools**). Finally, Section 2.6 draws the main conclusions.

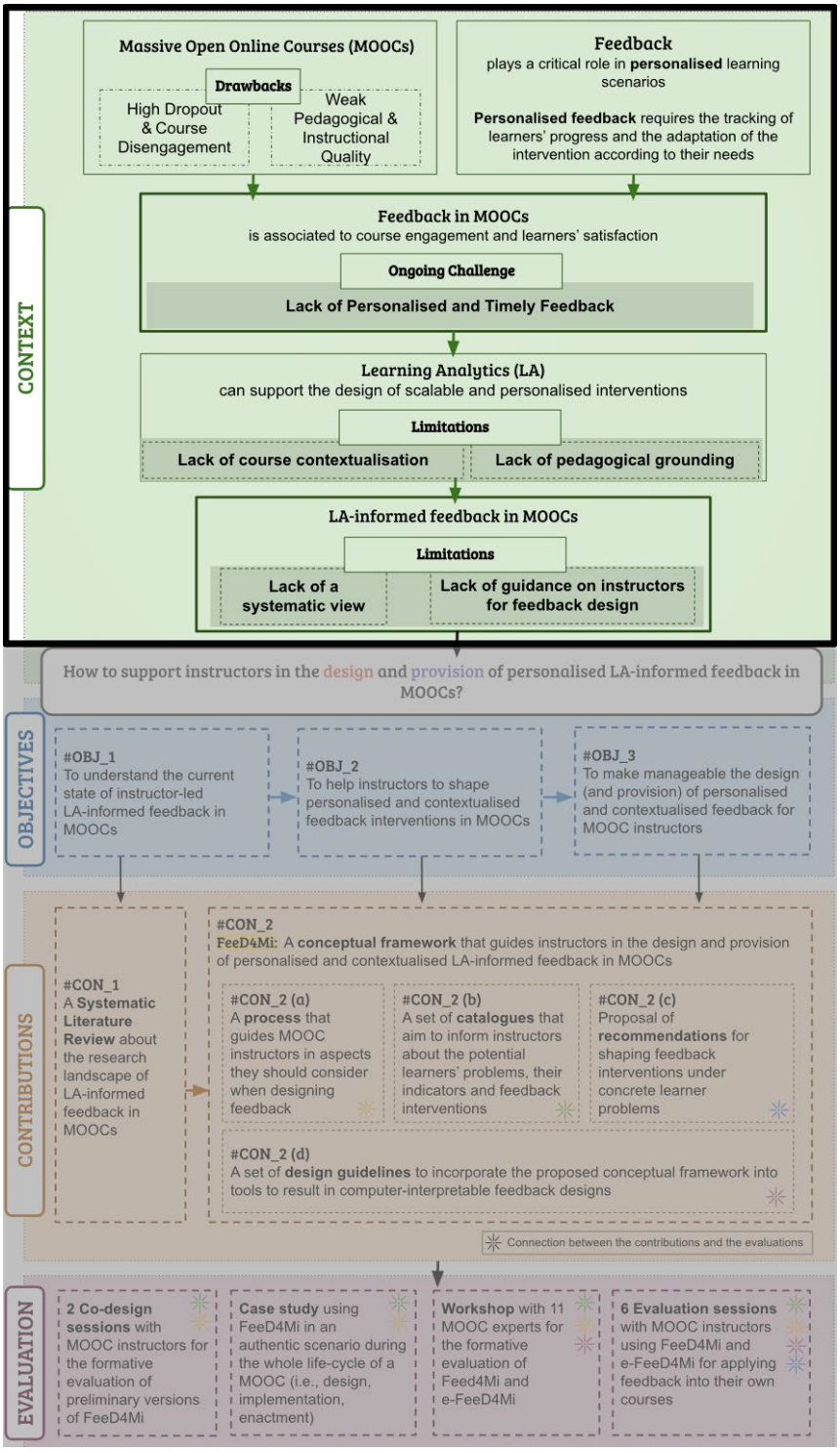


Figure 2.1. Research context of this dissertation.

2.2. Delving into MOOCs

MOOCs emerged within the open education movement (see Figure 2.2) which implies the universal access to high quality educational material (Siemens, 2013; UNESCO, 2019; Yang & Kinshuk, 2016). David Cormier and Bryan Alexander coined the term in 2008 to describe the online course "Connectivism and Connective Knowledge" developed by George Siemens and Stephen Downes (Cormier & Siemens, 2010). MOOCs initially were defined as online courses "*with the option of free and open registration, a publicly-shared curriculum and open-ended outcomes*" (Mcauley, Stewart, Siemens, & Cormier, 2010, p. 10). While MOOCs evolved since that definition, they continue maintaining their key features, i.e., openness, distribution, lifelong opportunities and participatory collaboration (Baturay, 2015; Kumar & Brahmbhatt, 2018). A closer look at the '*MOOC*' term illuminates how such courses differ from other forms of education:

- ***M****assive*: The first concept refers to large-scale participation (Siemens, 2013; Yousef, Chatti, Schroeder, Wosnitza, & Jakobs, 2015). This scalability regularly permits an unlimited number of enrolled learners that can interact with the course contents simultaneously (Yuan & Powell, 2018).
- ***O****pen*: The term 'open' regards the access to the learning material. Typically, MOOC platforms support the participation in the learning experience without geographic or financial constraints (Onah et al., 2014b; Siemens, 2013; Yousef et al., 2015). Nowadays there are some platforms, such as Coursera, which pose additional fees to the users for some course options (e.g., graded assignments, accreditation options), yet the main body of the course content remains without charges.
- ***O****nline*: The term 'online' describes the format of the courses which in principle is carried out exclusively through Internet (Siemens, 2013; Yousef et al., 2015), although MOOCs have been applied in other contexts as well such as blended learning (Bralić & Divjak, 2016). That is, the learning activity involves a variety of digital content (videos, documents, questionnaires, simulations, etc) and different opportunities to interact (learner-to-learner, learner-to-instructor) synchronously or asynchronously.
- ***C****ourses*: Compared to Open Educational Resources (OER), MOOCs regard a structured set of lessons dealing with a particular subject, normally organised under weekly modules, with a predefined study plan, concrete learning objectives, networking tools and assessment methods (Siemens, 2013; Yousef et al., 2015). There are two major modalities of MOOCs: a) instructor-led and b) self-paced (Calonge,

Riggs, Shah, & Cavanagh, 2018). The first modality considers courses with a predefined timeframe, a fixed start-end period, learning resources available based on instructors' study plan, and activities that learners need to accomplish on concrete dates. Self-paced MOOCs involve courses with a flexible timeframe, where the learning material always available for participants, and learners can adapt their learning path according to their needs.

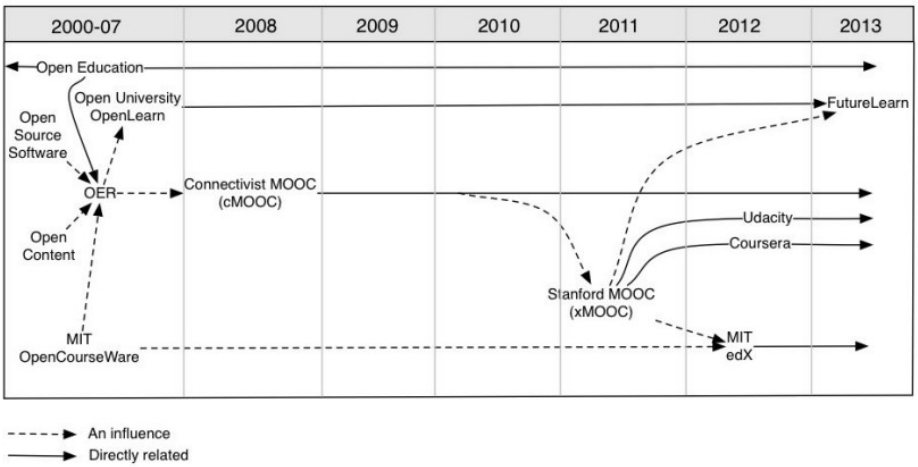


Figure 2.2. Timeline of MOOCs and Open Education (Yuan & Powell, 2018).

Another important feature of MOOCs, in comparison with blended or face-to-face learning, is that learners need to self-regulate their learning to achieve the course goals (Zhu, Bonk, & Doo, 2020). Thus, given the massive and open character of MOOCs, the control of learning is shifted from the instructors to the participants, who are expected to monitor and manage their learning experience (Alonso-Mencía et al., 2020; Milligan & Littlejohn, 2014).

During 2012, the MOOC movement became a major trend in education, with the creation of many platforms (i.e., EdX, Coursera, Udacity), and with the universities to start producing massive courses systematically (Yuan & Powell, 2018). The same year, The New York Times characterized 2012 as "*the year of the MOOC*" discussing the sudden MOOC hype, its potential and challenges that might accompany the courses (Pappano, 2012). Since then, MOOCs have grown rapidly attracting a lot of users among the years. COVID-19 pandemic prompted a new interest in MOOCs worldwide, with 2020 to become *"the Second Year of The MOOC"* (Shah, 2020). During this period, MOOCs served as alternative for remote learning from primary to tertiary educational levels (Chen et al., 2020; Ma & Rindlisbacher, 2020).

Currently, the impact of MOOCs can be witnessed by: a) statistics of use, b) the creation of new types of educational accreditations based on this learning model, and c) the growing number of MOOC providers. Concretely, by the end of 2021, 19.4k MOOCs were launched attracting over 220 million learners and offering 1670 micro-credentials (Figure 2.3) (Shah, 2021). Additionally, different ways of accreditation emerged, shaping new forms of courses, such as the MOOC-based online degrees (Ledwon & Ma, 2022). By 2021, 70 master's and bachelor's degrees were created around the world following the MOOC format (Shah, 2021). Attending to the MOOC providers, at present, there are more than 59,000 MOOC and online learning platforms at international (e.g., Coursera, Canvas, edX, Kadenze, Udacity) and national levels (e.g., MéxicoX in Mexico, FutureLearn in United Kingdom, Federica Web Learning in Italy, MOOC.fi in Finland, OpenHPI in Germany, Prometheus in Ukraine) (Shah, Pickard, & Ma, 2022).

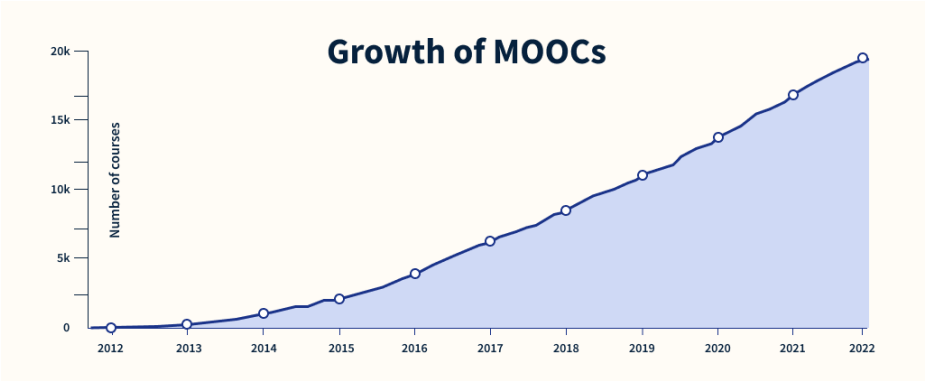


Figure 2.3. Growth of MOOCs by numbers (Shah, 2021).

2.3. Benefits and Challenges of MOOCs

MOOCs carry a variety of advantages both for learners and instructors. Learners state different reasons to enrol in MOOCs, including: studying a new subject or topic, updating their current knowledge, or certifying their skills (Hew & Cheung, 2014; Shapiro et al., 2017). Since their appearance in the educational landscape, MOOCs have been perceived as a means of democratizing education by providing learning content created by elite institutions for persons who possibly could not afford other learning alternatives (Dillahunt, Wang, & Teasley, 2014; Moura, Souza, Oliveira Neto, & Viana, 2017). Additionally, MOOCs support lifelong learning and sustainable solutions for professional development tailored to users' pace and timing (Brown, 2018; Shapiro et al., 2017). Furthermore, their open nature promotes participants' connections and collaborations (Ferguson & Sharples, 2014) and

thus encourages the creation of diverse learning communities, and communities of practice.

With regard to instructors, MOOCs provide opportunities of creating reusable educational resources and higher budget materials, of merging teaching models (e.g., flipped classroom) and of enhancing the learning process based on the users' input (Ferguson & Sharples, 2014; Hollands, 2014). At the same time, MOOCs also bring benefits to institutions: universities can promote themselves and their professors, disseminate their projects, attract more students and explore new research areas (Brown, 2018; Hollands, 2014). Hew and Cheung (2014) reported the professional visibility and the teaching experience to this massive learning setting among the reasons of delivering a MOOC from the instructor's perspective.

Nevertheless, and despite their potential, MOOCs are accompanied with several challenges. A major persisting problem regards the high drop-out rates of the courses. The low completion in MOOCs, often lower than 10% of the enrolled participants, is an issue discussed extensively in the literature (Goopio & Cheung, 2021; Khalil & Ebner, 2014). Nevertheless, Jordan (2014) noted that, according to MOOC nature, such low completions rates should not be interpreted merely in relation to MOOC success and learners' satisfaction. Indeed, there are many clusters of learners in MOOCs with different learning aims. For instance, participants who may continue passively the course or participants who register interested only in one concrete module. Thus, while dropout in MOOCs raises discussions and research interest, it cannot be associated to the course failure in all the cases (Liyanagunawardena, Parslow, & Williams, 2014). Among the factors leading to learner dropout regard: the course design (related to the course content and structure), the lack of interaction and the lack of personalised and timely feedback, the diversity of learners' background knowledge and the personal availability (Aldowah et al., 2020; Gregori et al., 2018; Henderikx, Kreijns, & Kalz, 2017; Hew, 2016; Hone & El Said, 2016; Khalil & Ebner, 2014; Onah, Sinclair, & Boyatt, 2014a; Refaat & Said, 2017).

Another ongoing challenge regards the pedagogical and instructional quality of MOOCs (Ferguson & Sharples, 2014; Gregori et al., 2018; Margaryan, Bianco, & Littlejohn, 2015). For years, the attention on MOOCs concerned on how to guarantee the scalable access to the learning content, thus, neglecting other factors linked with the course quality (Gregori et al., 2018). Such factors involve: the loose structure and the poor instructional design of the courses (El-Hmoudova, 2014; Gregori et al., 2018; Margaryan et al., 2015; Zhu et al., 2018), the lack of solid pedagogical approaches to guide the course design (Ferguson & Sharples, 2014), as well as the barriers in feedback and

personalised tutoring (Aldowah et al., 2020; Estrada-Molina & Fuentes-Cancell, 2022; Sari et al., 2020).

Among the aforementioned MOOC challenges, the current dissertation focuses on the difficulties of designing and providing personalised feedback in MOOCs, that regards a constant challenge within the last decade (Aldowah et al., 2020; Estrada-Molina & Fuentes-Cancell, 2022; Sari et al., 2020). Feedback is recognized as a fundamental facet of the learning process (Sawyer, 2006). In MOOCs the absence of personalised and on-time feedback has been associated with both learner disengagement (Aldowah et al., 2020; Gregori et al., 2018; Henderikx et al., 2017; Hone & El Said, 2016; Khalil & Ebner, 2014; Onah et al., 2014a; Refaat & Said, 2017) and the weak instructional quality of the courses that often support one-size-fits-all approaches (Aldowah et al., 2020; Margaryan et al., 2015). The next section discusses the importance of feedback in education, and Section 2.5 sheds light on feedback in MOOC contexts.

2.4. Feedback in Education

This section provides an overview on the importance of feedback in learning, presents different feedback models and recommends several aspects that should be considered to guarantee feedback interventions of high-quality.

2.4.1. Introducing Feedback

Hattie & Timperley described feedback as "*the information provided by an agent (e.g., teacher, peer, book, parent, self, experience) regarding aspects of one's performance or understanding*" (2007, p. 81). The notion of feedback was initially used in the 1940s in the field of rocket engineering describing the action of 'returning to an earlier position' within a mechanical process (Sanford, 2018). In the educational context, feedback is perceived as the main vehicle to help learners' attain the desired learning goals given their current state of understanding or performance (Hattie & Timperley, 2007). Historically, feedback served different roles depending on the various learning and psychological theories. Feedback was perceived: (a) as positive and negative reinforcements in Behaviourism, (b) as information that supports learners to process and develop their own knowledge in Constructivism or (c) as a mechanism to uncover learners' cognitive processes and explain and their subsequent behaviours in Cognitivism (Lipnevich & Panadero, 2021). Apart from the different feedback goals given the distinct pedagogical lenses, there is an evolution regarding the feedback provider. Traditionally, instructors were the main feedback agents (Sadler, 1989). Nevertheless, recent theories recognize the active roles that learners should take as feedback providers as

well, either within the context of self-feedback (Boud, 2000; Panadero, Lipnevich, & Broadbent, 2019) or peer feedback (Pitt, 2019). In online learning contexts, Gregori et al. (2018) comment three feedback providers: feedback received by the content (i.e., feedback that emerges from the instructional design and is embedded in course resources), feedback received by other learners (i.e., peer feedback) and instructor-led feedback (e.g., instructors' responses in forums).

Within the learning process, feedback is recognized as a determinant facet for all educational levels (Hattie & Timperley, 2007; Mory, 1996; Sawyer, 2006; Shute, 2008) with positive impact both on learners and educators (Al-Bashir, Kabir, & Rahman, 2016; Henderson, Ajjawi, Boud, & Molloy, 2019; Molloy & Boud, 2014). Al-Bashir et al. (2016) and Henderson et al. (2019) stated among the feedback benefits the improvement of learning outcomes, the adoption of more productive learning strategies, the increasement of learners' satisfaction and self-perception. Likewise, Molloy & Boud (2014) reported that feedback raises educators' awareness about learners' struggles and helps in enhancing the teaching practices.

2.4.2. Main Feedback Models and Recommendations

Literature reports various feedback models that illustrate the practices and the actors involved within the feedback processes. This section presents some of the most indicative models. Table 2.1 summarizes the differences and similarities of these models.

Sadler (1989) is among the first researchers who framed the notion of 'feedback' as part of learners' assessment defining it as "*the information given to the student about the quality of performance (knowledge of results)*" (p. 144). While he did not develop a feedback framework or model, Sadler set the foundations of the feedback conceptualization describing the features of formative feedback. Specifically, Sadler stated that learners' performance cannot be based solely on corrective feedback, as meaningful interventions result from 'direct qualitative human judgements'. He proposed, among others, the use of exemplars, descriptive statements, or the use of Bloom's taxonomy as effective feedback approaches to enlighten learners. Finally, Sadler stressed the importance on using feedback as a means for cultivating self-monitoring competences to learners. That way, learners could reduce their dependency on teachers, that he perceived as an unsustainable practice in learning.

Butler and Winne (1995) proposed a conceptual model that explained the effects of feedback at cognitive level and encouraged self-regulation. According to the model, the learners pass from the following four phases: a) the definition

of the learning tasks, b) the specification of the learning goals, c) the selection of the strategies to reach the goal, and d) the delivery of the product. During these phases, learners are at the centre of the learning process associating the task with learning goals and the strategies to be applied (i.e., internal feedback) and based on their results they refine their own strategies and the learning task. Later the instructor provides them with further information regarding the task to facilitate the refinement of the learning process (i.e., external feedback). Within this model, learners undergo continuous cycles of internal and external feedback that influence their learning performance. Nicol & Macfarlane (2006) suggested a model based on the proposal of Butler & Winne (1995). Their upgraded version highlighted further levels that the internal feedback may impact, such as cognitive, motivational, and behavioural ones. Additionally, the authors considered further agents as feedback providers, apart from the educators, such as peers, computers, or teaching assistants. The framework is aimed to guide the instructors to foster learners' self-regulation. To do so, the authors provide a list of principles to be considered when delivering feedback, such as concrete attention to the quality of the feedback information.

Mason & Bruning's model (2001) set the foundations on computer-based instruction in consideration with the individual differences of the learners. The authors proposed 8 different feedback types (e.g., correct/incorrect answers, elaborated answers) based on learners' performance level, the difficulty of the activity, prior knowledge, and the timing of feedback. The model provides a flowchart guiding the instructors on what kind of feedback is more adequate in different cases of learners' performance and task difficulty. On the same field, Dempsey & Wager suggested a taxonomy regarding the timing of feedback in computer-based instruction (1988). The authors provided several feedback ideas in relation to the feedback timing (i.e., immediate or delayed), the context of learning (i.e., computer-based learning or test), and the learners' outcomes.

Hattie & Timperley (2007) proposed a taxonomy about feedback, that is the most applied one in feedback literature and research (Lipnevich & Panadero, 2021). The authors listed four types of feedback. Concretely, they considered: (a) task-related feedback, focusing on the produced work checking in terms of completeness and correctness, (b) feedback at the process level, including comments about the process of the task, (c) self-regulatory feedback with comments about learners' self-management, and (d) feedback at self-level that includes praise and comments on the learners as persons and not about their task progress. From the above types, the first one is reported to be the most used in the teaching practice (Hattie & Timperley, 2007). The least

effective is considered the fourth one, as it is not instructive on how the learner should reach the desired learning goals (Hattie & Timperley, 2007).

Aben, Dingyloudi, Timmermans & Strijbos (2019) discussed how the participants of the feedback process (i.e., feedback provider and receiver) deal with errors, while sending or receiving feedback respectively. Thus, the authors shaped a model emphasising how personal characteristics (called as intrapersonal factors) and the perception the feedback receiver and provider have for each other (called as interpersonal factor) may affect the feedback process by resulting in more or less elaborated feedback and the acceptance or disagreement on the feedback received. Considering how intrapersonal factors influence feedback, Carless (2019) proposed the 3P model about the learner experience of feedback. The model consists of three phases -namely presage, process, product- and considers how the learner's personal characteristics (internal motivations, previous experience, etc.) together with the teaching context (assessment design, relational issues, etc) affect the learner's engagement with the feedback (i.e., process) and the impact of the feedback itself (i.e., product).

Apart from the feedback models, there are theories as well related to feedback, such as the Contingent Tutoring theory by Wood & Wood (1996). Contingent tutoring refers more to instructional scaffolding and examines the depth of the feedback tailored to learners' behaviours in a dialogic learning setting. Contingent Tutoring assumes that if the tutor supports the learners at an appropriate level, then the learners can improve their performance. The theory highlights three dimensions of contingent tutoring: a) the instructional contingency (i.e., how to support the students), b) the domain contingency (i.e., how to deliver feedback in respect to students' level of domain knowledge) and c) the temporal contingency (i.e., when the tutor should intervene). The authors propose five levels of feedback (e.g., hints, general feedback messages, concrete instructions) depending on learners' progress and their response to feedback. Some years later, Wood & Wood raised the attention on the changes on the feedback in computer-assisted learning contexts, highlighting the need to foster help-seeking behaviours and on how to avoid potential mistreatment of the instructional feedback (1999).

All the above models propose aspects to be considered within different learning and feedback situations (e.g., self-regulated learning, computer-assisted learning). According to previous literature, the feedback effectiveness differs depending on the learning context (Mory, 1996), with each model to be more useful under the concrete the paradigm it served. Yet, in spite of their variability, there is a consensus about the feedback message to be delivered; that is to inform the feedback receiver about: (a) the discrepancy between the

current and the desired state of the learner and (b) the strategies to bridge such gap.

Table 2.1. Summary of the presented feedback models.

Authors	Aim	Output	Involved Stakeholders		
			Teachers	***Students***	***Others***
Dempsey & Wager (1988)	To describe different types of feedback in computer-based settings	The proposal of a classification matrix with types of immediate and delayed feedback	✓	✓	Computer
Sadler (1989)	To reduce the gap between the actual and desired levels of students' performance	The development of students' self-monitoring skills with the teachers' help	✓	✓	×
Butler & Winne (1995)	To describe how internal and external feedback affects students' learning	The comprehension of the continuous cycles of internal and external feedback that learners experience	✓	✓	x
Wood & Wood (1996)	To explain the depth of the feedback tailored to learners' behaviours	The provision of five levels of feedback given the learners' progress and response to feedback	✓	✓	Computer
Mason & Bruning (2001)	To describe feedback in computer-based contexts given the individual students' traits	The provision of 8 types of feedback considering the student achievement, the task level, the prior knowledge, and the feedback timing	✓	✓	Computer
Nicol & Macfarlane (2006)	To use feedback for empowering self-regulation	The development of self-regulation process	✓	✓	Peers, teaching employees
Hattie & Timperley (2007)	To detect the circumstances under which feedback has the greatest impact	The proposal of four areas of feedback focus feedback	✓	✓	Peers, parents
Aben, Dingyloudi, Timmermans & Strijbos (2019)	To explain how the learners and teachers deal with errors while sending or receiving feedback	The comprehension on how personal qualities and the perception of the feedback receiver/provider affect the acceptance of feedback	✓	✓	Peers
Carless (2019)	To explain how the individual qualities and the context affect the feedback impact	The development of learners' feedback literacy	✓	✓	x

Over the years, research reported several aspects that the feedback provider should consider in order to increase the effectiveness of the interventions. For instance, Hattie & Timperley (2007) deemed that constructive feedback is necessary to meet the threefold: (a) definition of the learner goals, (b) concretization of the approach needed to reach the set goals, (c) identification of the future steps needed to enhance the progress. These objectives correspond to the concepts of *feed-up, feed-back and feed-forward* respectively. During this process, learners are expected to recognize the gap between their current point and the point they need to reach, their progress and the process required to enhance their learning and their further activity towards improvement. To facilitate this process, feedback providers should support a learning environment encouraging self-assessment and self-regulation (Hattie & Timperley, 2007).

Previous research reports that prior learner skills, behaviours and perceptions may affect learners' engagement with the received feedback, the goal orientation and self-efficacy (Carless, 2019; Mory, 1996; Narciss & Huth, 2002). For instance, according to Narciss & Huth (2002) feedback needs to be designed under the following parameters to be successful: a) the aim of feedback (e.g., motivational, cognitive), b) the instructional context (e.g., learning objectives and learning tasks), and c) the individual characteristics of the learners (e.g., prior knowledge and skills, motivation). Similarly, feedback should include the expected objectives, the guidelines on how to achieve such objectives and the suggestions for future improvements (Narciss & Huth, 2002). Other critical aspects when designing feedback interventions involve the depth and extent of the feedback to avoid cognitive overload, the type of feedback and the clarity of the transmitted message.

Shute (2008) focused on 'formative feedback' defining it as *"the information communicated to the learner that is intended to modify his or her thinking or behaviour for the purpose of improving learning*" (p.154). After an extensive review of the literature, she provided a catalogue of different types of interventions (e.g., corrective feedback, elaborated feedback, more attempts, cues and hints). Additionally, Shute generated a set of guidelines aimed to propose several actions to be follow and to avoid when designing formative feedback interventions. Among such actions we find proposals as: "*provide feedback after learners have attempted a solution*", "*promote a "learning" goal orientation via feedback*" or "*do not interrupt learner with feedback if the learner is actively engaged*" (p.176-177).

Molloy & Boud (2014) listed three aspects that influence feedback quality, based on previous literature, related to the: (a) content, (b) timing and (c) provider qualities of feedback. The authors highlight the need of a balance in

the feedback message; that is, to communicate the performance state and strategies to deal with the performance discrepancies and the same time to be both critical and constructive without disengaging the learner. Moreover, the authors find that the qualities of the feedback provider may influence the way learners perceive and respond to feedback. For instance, peer feedback tends to be questionable by the learners than feedback delivered from the educator, as being the expert of the learning topic (Molloy & Boud, 2014; Onah et al., 2014a). Similarly, Aben et al. (2019) argued that the interpersonal perceptions and relationships influence the feedback interventions. Finally, Molloy & Boud (2014) brought up the issue of the feedback timing, with both delayed and immediate interventions to be effective given the learning objectives. Mason & Bruning (2001) and Hattie & Timperley (2007) discussed as well about the feedback timing, with the first ones to associated the feedback timing with the learners' performance state. According to their proposal, immediate feedback is more effective for lower-performance learners and delayed feedback for higher-performance learners.

In summary, this section provided an overview of the feedback models and recommendations reported in the literature. The above review helped us to select the feedback model that guides FeeD4Mi, the conceptual framework proposed in the current dissertation (#CON_2), and to design its process according to the above recommendations and suggestions. Specifically, as we present in Chapter 5, FeeD4Mi follows the feedback taxonomy by Hattie and Timperley (2007). Nevertheless, other models, such as the one of Mason & Bruning (2001), inspired particular aspects of the framework, i.e., the consideration of the feedback timing in the proposed FeeD4Mi process. Additionally, the FeeD4Mi catalogues apply the proposals suggested by Mason & Bruning (2001), Molloy & Boud (2014), Shute (2008) and Wood et al. (1995).

2.5. Feedback in MOOCs

Tailored feedback interventions require instructors to track learners' individual progress by collecting evidence of their actions and then, shape interventions accordingly (e.g., choose the type and depth of feedback) (Mason & Bruning, 2001; van de Pol et al., 2010; Wood et al., 1995). More conventional learning environments (e.g., face-to-face teaching) allow direct monitoring of learners, favouring the identification of problems and the selection of appropriate support (Leibold & Schwarz, 2015). In contrast, in blended or fully online learning cases the synchronous tracking of learners and the delivery of on-time and personalised of interventions gets challenging (Ryan, Gašević, & Henderson, 2019). Therefore, the identification of learners' problems and the design of adequate feedback in these environments requires special attention

(Leibold & Schwarz, 2015). MOOCs represent an example of such learning environments, where the provision of scalable feedback tailored to learners' needs and behaviours is complex (Aldowah et al., 2020; Estrada-Molina & Fuentes-Cancell, 2022; Sari et al., 2020). While feedback has been associated to learners' course engagement (Aldowah et al., 2020; Khalil & Ebner, 2014; Onah et al., 2014a), it is rather overlooked in MOOCs (Estrada-Molina & Fuentes-Cancell, 2022; Gregori et al., 2018).

Discussion forums represent the primary hub in MOOCs, where feedback and social learning take place (Almatrafi et al., 2018; Onah et al., 2014b), enabling learners to communicate their doubts, and instructors, teaching assistants (TAs) or peers to support them (Sari et al., 2020). Yet, the provision of timely and personalised feedback through discussion forums is challenging, due to:

- The high learners-instructor or TAs ratio (Almatrafi et al., 2018), the asynchronous course interaction and the manual answer to every learners' post (Shatnawi, Gaber, & Cocea, 2014; Zheng et al., 2016). The above aspects hinder the learners' monitoring regarding their course involvement and progress. To face this ratio-related problem, MOOC instructors usually rely on peer support. However, assistance received by peers is not as effective as the one received by course instructors to increase learners' engagement (Gregori et al., 2018).
- The high diversity of learners' background knowledge and cultural aspects which results in provision of generic support that does not meet the individual needs (DeBoer, Seaton, & Breslow, 2013)
- The limited participation in discussion forums from the average learner populations (less 10% of the population) (Onah et al., 2014b; Wise & Cui, 2018). Indeed, while discussion forums gather a high number of posts, such posts usually come from learners who tend to communicate easier and the average population might hesitate to speak out (Douglas, Zielinski, Merzdorf, Diefes-Dux, & Bermel, 2019).

Considering Gregori et al. proposal (2018) of the three main means of feedback in online learning (i.e., content, peer, instructor-led feedback), in MOOCs other ways of obtaining feedback apart from discussion forums regard: (a) quizzes and test including automated feedback messages about the current/wrong answers (Gregori et al., 2018; Sari et al., 2020; Shatnawi et al., 2014), and (b) platform notifications and emails about course milestones (Lowenthal, Snelson, & Perkins, 2018; Zhu et al., 2018). Nevertheless, prior research described learners' negative perspectives on computer-based automated grading and feedback, because many times they want more elaborated comments and reviews (Vinker & Rubinstein, 2022).

Instructors[3] recognize feedback among their main challenges when designing MOOCs (Pappano, 2012; Sari et al., 2020), expressing their desire to shape and deliver more personalised and timely feedback for larger learner cohorts (Zheng et al., 2016). According to Gregori et al. (2018) and Hone & El Said (2016), increasing instructors' presence through feedback provision in MOOCs may impact positively the learning process and learners' engagement. To overcome the constraints that accompany the manual feedback interventions, the use of LA has been proposed (Pardo, Jovanovic, Dawson, Gašević, & Mirriahi, 2017).

The field of LA aims to understand and enhance the learning process by offering insights on the learners' course behaviours based on their digital trace data (Dawson, Gašević, Siemens, & Joksimovic, 2014). LA include a wide range of methods for optimising learner support and seem promising for scaling up the feedback interventions (Khalil & Ebner, 2016; Tsai, 2017). In MOOCs, one common example of the use of LA are dashboards that display learners' activity (e.g., time spent on a task, number of attempts of an activity, number of logins). Dashboards may facilitate instructors' awareness on behaviours that need further attention, and thus facilitate instructors on carrying out targeted interventions (Urrutia, Cobos, Dickens, White, & Davis, 2016). Another way of using LA to shape feedback interventions is the use of predictive analytics. Researchers have been applying predictive models to automatically identify struggling learners or learners at risk of dropout (Bouzayane & Saad, 2017; Halawa et al., 2014; Xing, Chen, Stein, & Marcinkowski, 2016; Yang et al., 2013). With these systems, instructors can be alerted. For instance, Teusner, Hille, & Staubitz (2018) explored the possibility of identifying MOOC learners struggling with programming activities by examining the number of code execution and the total worktime spent and then support them.

While the above approaches may provide support to MOOC instructors, empirical research in higher education and online learning settings reports that LA tools often lack pedagogical foundations from learning theory and course contextualisation (Jivet et al., 2017; Matcha et al., 2020; Schwendimann et al., 2017). For example, information displayed by LA dashboards often regards aggregated data that mismatch with instructors' needs. For example, Stephens-Martínez, Hearst, & Fox (2014) conducted a survey with 92 MOOC

[3]As stated in Section 1.1, the current dissertation focuses on instructor-led feedback, i.e., feedback designed and shaped by the instructor. In MOOCs there are other roles (e.g., instructional designers, teaching assistants) often undertaking teacherly roles. For simplicity, we employ the term 'instructor', although we do recognize the possible involvement of more roles in the design and provision of feedback.

instructors and found that, while instructors were eager to detect learners who face problems, they tend to prefer discussion forums more than dashboards as a monitoring resource. Similarly, Liu et al. (Liu et al., 2017) and Shibani (2019) highlighted the limitation of several predictive models that capture metrics without considering the particularities of the course, as predictive models strive for generalisability of their results. Liu et al., (2017), Papamitsiou (2020) and Rodríguez-Triana et al. (2015) argued that, if those analytics systems consider information associated to the LD, they can suggest more meaningful interventions. The successful use of LA may be inhibited as well due to the lack of user confidence because of poor competences (Quadri & Shukor, 2021) or lack of a human-centred design (Shum et al., 2019). In that direction, Mangaroska & Giannakos (2019) highlighted the need for providing guidance to the course instructors to understand, use and reflect on LA and connect it to the LD.

Conclusively, building on the need of using LA-informed feedback to shape personalised and timely interventions in MOOCs, it seems necessary to consider, apart from scaling up the feedback opportunities, the pedagogical grounding, the course LD and the specific needs of the feedback providers. Additionally, given the fact that the abovementioned LA limitations were detected in learning contexts different than MOOCs (i.e., Higher Education and online learning), a systematic review on the use of LA tools to support the design and delivery of feedback in MOOCs is needed to drive further conclusions on the benefits and limitations of LA in informing interventions in MOOCs.

2.6. Conclusions

MOOCs shifted the educational landscape offering open, distributed, and structured learning activities, supporting lifelong opportunities and possibilities for connection among individuals (Ferguson & Sharples, 2014; Kumar & Brahmbhatt, 2018; Siemens, 2013). In spite of their educational benefits and their global adoption, MOOCs are accompanied by several challenges that affect the learning experience. Among such challenges there is the difficulty in providing personalised and timely feedback (Aldowah et al., 2020; Estrada-Molina & Fuentes-Cancell, 2022; Sari et al., 2020).

The current dissertation focuses on how to support the provision of instructor-led prompt and personalised feedback in MOOCs. This chapter explored the limitations of instructor-led feedback in MOOCs and provided an overview of various feedback models and guidelines that, when considered, may lead to more successful feedback. To wrap up the presented ideas, instructor-led feedback in MOOCs can be provided through discussion forums,

notifications, emails, and automated graded assignments and quizzes. Nevertheless, these approaches are neither sustainable for large learner cohorts (i.e., answers in forums) (Shatnawi et al., 2014; Zheng et al., 2016), nor personalise instructors' interventions (i.e., automated grades) (Vinker & Rubinstein, 2022).

To overcome such limitations, we propose the use of LA-informed feedback, that can support scalable and personalised interventions. However, to result in meaningful interventions and be useful for the instructors, the LA tools should entail a pedagogical basis (Jivet et al., 2017; Matcha et al., 2020; Schwendimann et al., 2017) and a course contextualisation (Liu et al., 2017; Shibani et al., 2019). Accordingly, we deem it relevant to know the possibilities that the current proposals offer in MOOCs, whether they are pedagogically grounded and whether they take into account the course context and the feedback literacy (e.g., recommendations of different types of feedback based on learners' progress) (see Chapter 4). This information would permit us to shape proposals facilitating instructors in the design and provision of personalised and timely feedback interventions in massive contexts (see Chapter 5).

Chapter three

EXPLORING THE LEARNERS' & INSTRUCTORS' CONSTRAINS IN MOOCS

Summary: The current chapter presents the ***exploratory studies*** carried out at the first DBR cycle. In total, we conducted three exploratory studies **involving as informants both learners and instructors**. This approach allowed a deeper understanding on the needs and viewpoints of both stakeholders in MOOC settings. The first two exploratory studies focused on the problems that learners face during the course enactment and on the learners' course behaviour when attempting to overcome their problems. The third study targeted MOOC instructors and shed light into the strategies they employ and the challenges they face in relation to the design and provision of feedback. The obtained results informed the research objectives and contributions of this dissertation, as presented in the first chapter. This chapter outlines the context of the studies, the research methods, and the main findings obtained. The complete studies are published in different venues.

This Chapter is based on the following publications:

Topali, P., Ortega-Arranz, A., Er, E., Martínez-Monés, A., Villagrá-Sobrino, S.L., Dimitriadis, Y. (2019). Exploring the Problems Experienced by Learners in a MOOC Implementing Active Learning Pedagogies. In: *Proceedings of the 2019 EMOOCs Conference*. Springer, Cham., pp. 81–90.

Topali, P., Ortega-Arranz, A., Dimitriadis, Y., Martínez-Monés, A., Villagrá-Sobrino, S.L., Asensio-Pérez, J.I. (2019). "Error 404- Struggling Learners Not Found" Exploring the Behaviour of MOOC Learners. In: *Proceedings of the 15th Conference on Technology-Enhanced Learning*. Springer, Cham., pp. 636–639.

Topali, P., Ortega-Arranz, A., Martínez-Monés, A., & Villagrá-Sobrino, S. L. (2021). "Houston, we have a problem": Revealing MOOC practitioners' experiences regarding feedback provision to learners facing difficulties. *Computer Applications in Engineering Education, 29*(4), 769–785.

3.1. Introduction

The current dissertation aims at supporting MOOC instructors in the design and delivery of personalised LA-informed feedback in MOOCs. As discussed in Chapter 1, to address this goal we involve the course instructors in the process of defining behaviours of struggling learners and aspects related to feedback (e.g., feedback timing, type of feedback intervention). Therefore, during the first DBR cycle, we conducted three exploratory studies to understand instructors' practices and challenges in the process of feedback provision in MOOCs. At the same time, we explored recurrent learners' problems occurred during the MOOC enactment.

This chapter presents a synthesis of the conducted exploratory work and discusses the obtained findings, which shaped our thesis proposals. Specifically, we run three exploratory studies, two of which (i.e., [Exp_1] and [Exp_2]) focused on learners' problems and the help-seeking strategies applied in authentic MOOC scenarios. The third one (i.e., [Exp_3]) regarded semi-structured interviews with MOOC instructors exploring their challenges related to the design and delivery of feedback. Figure 3.1 illustrates how each study contributed to the dissertation proposals.

The structure of the current chapter is as follows. Section 3.2 provides an overview of the first and second exploratory study and the obtained results that had as informants the MOOC learners. Section 3.3 reports the third exploratory study and the evidence gathered. Next, Section 3.4 discusses the findings obtained from the three exploratory studies. Finally, Section 3.5 outlines some relevant conclusions from these exploratory studies.

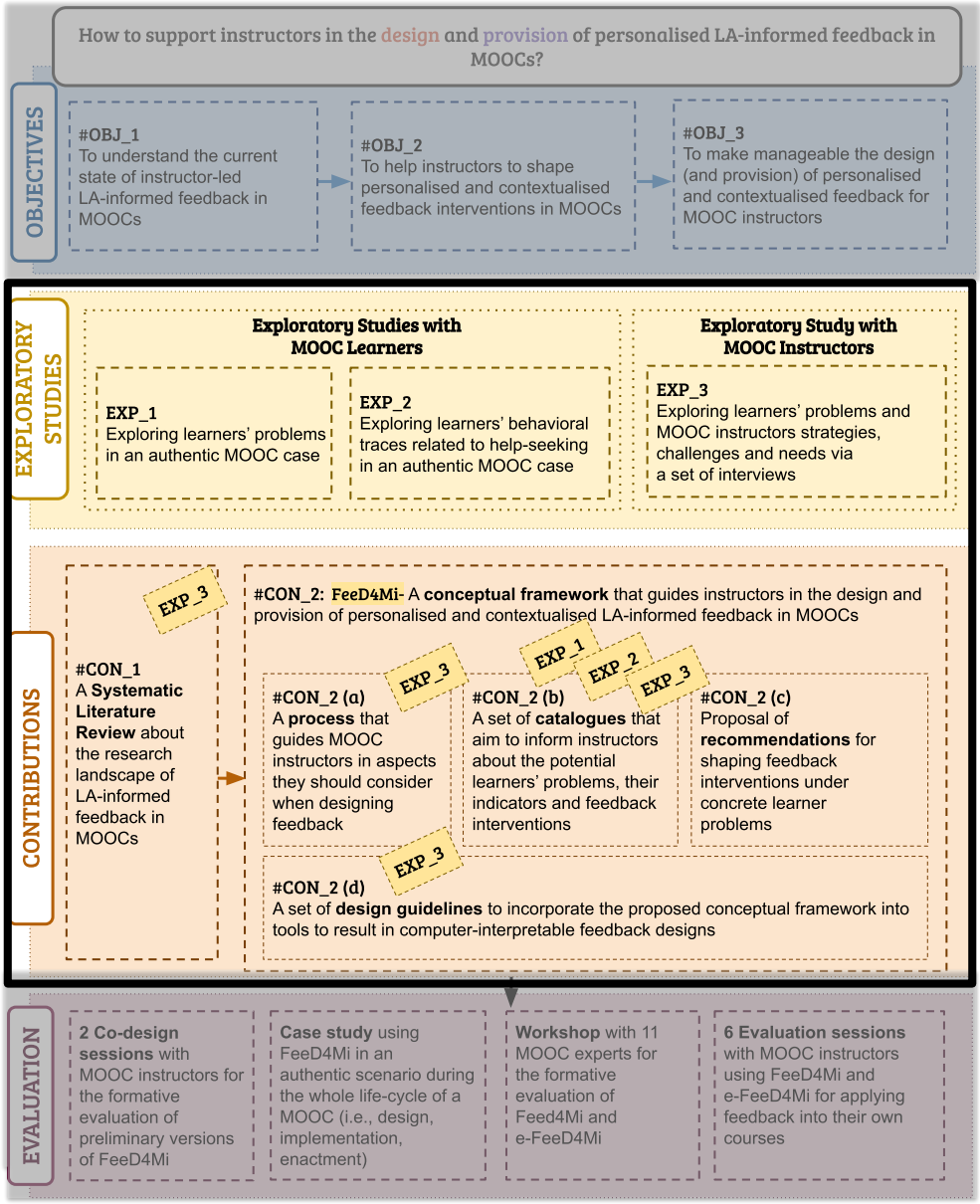


Figure 3.1. Overview of the exploratory studies addressed in Chapter 3 and their association with the contribution.

3.2. Exploratory Studies with MOOC Learners

This section presents an overview of the first two exploratory studies (i.e., [Exp_1] and [Exp_2]) that took place from March to June 2018 in an authentic MOOC context. Building on the general objective of this dissertation, we deemed essential to understand a) the problems that learners face during the MOOC enactment ([Exp_1]) and b) the help-seeking behaviours that learners employ to identify learners who need additional support ([Expl_2]). Exploring these aspects permitted the collection of a set of problems that MOOC learners often face. Additionally, we spotted potential behaviours of struggling learners, that could propose more informative solutions to instructors to assist their learners. These exploratory studies also served us to better comprehend the context of MOOCs and its particularities in learners-to-instructor interaction.

The two studies occurred in the MOOC *Por los mares de la traducción económico-financiera 2ed (EN-ES)* [4], which was the second edition of a course about English-Spanish translation of financial and business terms. The MOOC was delivered in the Canvas Network platform[5] from the University of Valladolid. The MOOC contained seven weekly modules with video lectures and pdf readings, additional learning resources, two different forums (i.e., discussion forums and group discussion forums), social networks (e.g., Facebook) and various individual and group assignments. The estimated workload was 3 hours per week. Out of the 866 learners registered at the course, 169 received the final certificate (19.52% percentage of completion). A prerequisite to obtain the certificate was the completement of all compulsory assignments.

The MOOC instructor implemented active learning strategies, such as gamification and collaboration into the course design. Bonwell & Eison (1991, p. 2) describe active learning as "*involving students in doing things and thinking about what they are doing*". Accordingly, the use of gamification and collaboration was foreseen as an opportunity to boost learner-to-learner and learner-to-content interaction. One main instructor, with the role of designing all the activities and assisting the learners, and two TAs, who assisted the learners as well, composed the MOOC teaching team. Both the instructor and the TAs devoted a lot of effort solving learners' doubts and providing frequent feedback both at the discussion forums and at the private messages, a case not so common generally in MOOCs.

[4] https://www.classcentral.com/course/canvas-network-por-los-mares-de-la-traduccion-economico-financiera-2ed-en-es-8014
[5] https://www.canvas.net/

3.2.1. Overview of the First Exploratory Study [Exp_1]

The first exploratory study [Exp_1] addressed the following research question: *"Which problems do learners experience in a MOOC implementing active learning strategies?"*. To address this question, we defined the following sub-questions:

- RQ1: What were the problems faced by the learners who successfully completed the course?
- RQ2: What were the problems faced by the learners who dropped out of the course?

To answer these questions, we followed a mixed method approach and more specifically, a Convergent Parallel Design (Creswell & Plano-Clark, 2009). A Convergent Parallel Design requires the collection and analysis of both qualitative and quantitative data to support a thorough understanding of the obtained evidence. Table 3.1 introduces the data sources applied in [Exp_1].

Table 3.1. Data sources applied in [Exp_1].

Label	Data Source	Description	N
[Post_Quest]	Post-course Questionnaire	Questionnaire distributed at the end of the course regarding: a) the help-seeking strategies the learners applied b) the problems that learners faced The questionnaire was composed by several open-ended and closed questions, including multiple-choice and 4-point Likert-scale items (ranging from *I strongly disagree* to *I strongly agree* and an *I don't know/No answer* options).	174
[Drop_Quest]	Dropout Questionnaire	Questionnaire distributed at the end of the course to dropout learners exploring the reasons for quitting the course. This questionnaire consisted of two multiple choice and one open-ended items. The participants indicated the aspects of the course that were more challenging to follow and suggested improvements that would have helped them to keep up with the course.	69
[GeneralForums]	Discussion Forums' Posts	Learners' messages (entries, replies) in the discussion forums of each module.	156
[Group_Forums]	Discussion Group Forums	Learners' messages (entries, replies) posted in the group discussion forums associated with the two collaborative activities of the course.	2,213
[Priv_Mess]	Private Messages	Learners' email messages sent privately to the instructors.	39

3.2.2. Overview of the Second Exploratory Study [Exp_2]

The second exploratory study [Exp_2] addressed the following RQ: *"To what extent the learners' behavioural indicators provide useful information for the identification of learners who face problems during a MOOC?"*. To better understand this question, we identified the following sub-questions:

- RQ1: Which are the differences in the behavioural engagement of MOOC learners reporting problems depending on whom they turned for help?
- RQ2: To what extent is it possible to identify learners who face problems by looking at their effort before asking for help?
- RQ3: Is there any kind of common behaviour among the MOOC learners who reported problems before asking for help?

To answer the aforementioned questions, we applied a mixed method approach and concretely a Concurrent Nested Design (Creswell & Plano-Clark, 2009). According to Concurrent Nested Design, more emphasis is given to quantitative data, while qualitative information serves as a secondary data set. In our case qualitative data used to support RQ1 and RQ3. Table 3.2 presents the multiple data sources used in this study.

Table 3.2. Data sources applied in [Exp_2].

Label	Data Source	Description	N
[Post_ Quest]	Post-Course Questionnaire	Questionnaire distributed at the end of the course regarding the help-seeking strategies the learners applied. The questionnaire was composed of one open-ended and 3 closed questions, i.e., multiple choice item and 4-point Likert-scale items (ranging from *I strongly disagree* to *I strongly agree* and an *I don't know/No answer* option).	174
[GeneralForum]	Discussion Forums' Posts	Learners' messages (entries, replies) in the discussion forums of each module.	156
[Priv_ Mess]	Private Messages	Learners' email messages sent privately to the instructors.	38
[Logs]	MOOC platform logs	Learners' trace data during the course. We examined the features of forum posts, assignments' submissions, pageviews and the total time spent in the course.	-

In both [Exp_1] and [Exp_2] the data (e.g., pageviews) were retrieved from the Canvas Network platform. Before the data collection, learners were informed about the aim of the studies and authorized the use of their data for research purposes. Regarding the data analysis, the closed items from the post-questionnaire, together with the learners' logs were analysed quantitatively with descriptive statistics and were processed using the RStudio software. We further employed content analysis on learners' self-reported data, such as posts in discussion forums, private messages, and open-ended questions in the

post-course questionnaire. During the qualitative coding process emerged categories both etic (i.e., predefined categories from the literature) and emic (i.e., categories emerged from learners' self-reported data) (Given, 2012). To increase the credibility of the studies, we carried out triangulation among the data sources, and peer debriefing among the members of the research team during the refinement of the questionnaires' items to warrantee the content validity (Fraenkel, Wallen, & Hyun, 2012; Guba, 1981).

3.2.3. Results of the Exploratory Studies [Exp_1] & [Exp_2]

This section presents the core findings obtained from both studies, i.e., [Exp_1] and [Exp_2], addressing the exploratory questions indicated in Sections 3.2.1 and 3.2.2. The work of Topali, Ortega-Arranz, Er et al. (2019) provides further details about [Exp_1]. Likewise, the work of Topali, Ortega-Arranz, Dimitriadis et al. (2019) provides more information about [Exp_2].

Results of the First Exploratory Study [Exp_1]

As stated previously, [Exp_1] addressed the following research question: *"Which problems do learners experience in a MOOC implementing active learning strategies?"*. This subsection describes the main findings associated to the RQs mentioned in Section 3.2.1. Different excerpts of evidence support the findings.

RQ1: What were the problems faced by the learners who completed the course successfully?

The main problem mentioned by the learners (64%) in the [Post_Quest] was related to the collaboration with peers and group members in group activities. Learners noted as a barrier the lack of smooth communication with their colleagues (see Table 3.3, [Post_ Quest] A). We further triangulated such evidence with learners' posts in discussion forums and group forums. Indeed, during the fourth week of the course 16 entries (out of 29) in the [GeneralForum] were complains about absent members that hindered the timely delivery of the assignments (see Table 3.3, [GeneralForum] A). Similarly, in [Group_Forums] many posts remained without replies and learners expressed their dissatisfaction among each other.

The second challenge reported in the [Post_Quest] (53%) was related to the workload of the course, which learners perceived as quite high. In fact, during the course enactment many of the messages ([Priv_Mess]) sent to the teaching team (n=14 out of 39 messages) dealt with requests to extend the deadlines (see Table 3.3, [Priv_ Mess] A). 32% of the learners also highlighted ([Post_Quest]) several activity-related problems, e.g., content understanding or difficulties for peer evaluation (see Table 3.3, [Post_ Quest] B). A total number

of 8 out of the 39 messages ([Priv_Mess]) attended by the course instructor concerned learners' problems with the course activities. Finally, minor learners' problems were related to difficulties on following the recommended learning path ([Priv_Mess]), and several technical problems, e.g., connection problems or disabled links ([Post_Quest]).

RQ2: What were the problems faced by the learners who dropped out of the course?

To begin with, we considered as dropout learners those who filled out the initial questionnaire, indicating some interest for the MOOC, but skipped at least one compulsory activity, and thus, did not obtain the course certificate. A total number of 468 learners quitted the course. After being in contact with these learners, 69 of them answered the final questionnaire [Drop_Quest].

Lack of time to invest in the course, due to personal reasons, was the most reported problem (n=44 replies in [Drop_Quest]) (see Table 3.3, [Drop_Quest] A). Some learners mentioned their disengagement with the course, due to different expectations with the MOOC content (n= 10 in [Drop_Quest]). Fewer learners (n=9) stated that they could not cope with several learning problems, due to their lack of previous background and the need of additional assistance and thus they quitted the course. From the 69 dropout learners who replied to the [Drop_Quest], we found that most of them reached the second week of the MOOC complementing the compulsory activities proposed by that period.

Table 3.3. Selected excerpts of evidence [Exp_1].

Data Source	Excerpt
[Post_ Quest]	A. *The only problem I faced during the course was that coordination in the group was not an easy task, probably due to time differences between participants and the poor communication* B. *Without having experience in economic translation [..] it has been sometimes difficult to understand certain concepts/ terms. For this reason, some of the translation tasks have turned out to be more complex than expected. In general, I think it has been an intense course. [..]*
[GeneralForum]	A. *Hello! What happens if from the group of 6 only two people propose terms when it is time to deliver? Are we two the responsible for gathering the 20 terms? I tried to communicate with the other members of the group, but I cannot find how to send them a message and this doubt arose for the hypothetical case that they do not appear in the group forum*
[Priv_ Mess]	A. *I get in touch with you to indicate a problem that has arisen to two other learners of the course and me. From the 23rd to the 30th of April we have a few days of the master's degree that we are studying in Brussels, and we will not be able to complete the last task in the established time. Would there be any possibility of doing it before or after those dates?*
[Drop_Quest]	A. *When I started the course, I had more time but with two jobs finally I had to leave it due to lack of time*

Results of the Second Exploratory Study [Exp_2]

[Exp_2] focus on the following research question: "*To what extent the learners' behavioural indicators provide useful information for the identification of learners who face problems during a MOOC?*". This subsection describes the main findings associated to the RQs mentioned in Section 3.2.2 and supports them with different excerpts of evidence.

RQ1: Which are the differences in the behavioural engagement of MOOC learners reporting problems depending on whom they turned for help?

With respect to whom learners turned for help when facing a problem, 20,35% of the participants preferred to ask only the instructors (IH: Instructor Help), 9,30% other peers (PH: Peer Help), 44,19% everyone who could provide them help (EH: Everyone Help), and 25% preferred not to report their problems at all (NH: No Help). Complementing the self-reported data of the [Post_ Quest] with the log data from the course, we found that, out of the 35 students of the IH cohort, only 5 of them sent private messages to the instructors. This suggests that, although learners preferred to contact the course instructor about their problems, most IH learners were expecting answers in discussion forums. Moreover, out of 16 learners of the PH cohort, only 7 of them posted in discussion forums, apparently showing that the remaining learners used other different means to ask help from peers (e.g., social networks or face-to-face peers). Finally, out of 43 learners of the NH cohort, 20 learners posted in discussion forums and 2 sent private messages. This result reveals that, while many learners contacted instructors and peers, in most cases they were not communicating an actual problem.

We explored learners' behavioural activity based on the number of pageviews, the number of assignment submissions, the number of forum posts (entries and replies) and the total time spent in the course, variables typically used in the literature to this end (Henrie, Halverson, & Graham, 2015). According to Figure 3.2, on average, the learners from the IH cohort were more active than the learners from the other cohorts. To statistically compare these differences, a z-test (Navidi, 2008) was performed among the IH, EH, and NH cohorts. Results (see Figure 3.3) illustrate significant differences between the IH and NH cohorts (on average, 157.36 pageviews, 0.86 submissions and 2.20 posts more) and between the IH and EH cohorts (on average, 141.60 pageviews and 0.72 submissions more). Additionally, although a statistical test between the PH and the other cohorts was not performed, due to the test assumption limitations, the PH cohort was less active than the IH and EH cohorts (on average, 223.26 and 81.66 pageviews, 2.16 and 2.78 posts, 324.77 and 68.81 activity minutes less respectively).

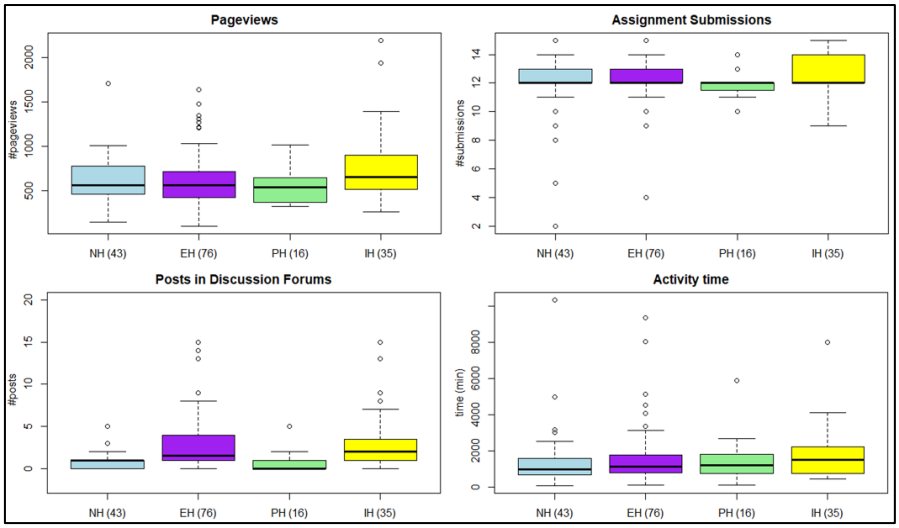


Figure 3.2. Behavioural analysis boxplot comparison between cohorts of participants based on their experiences towards solving problems.

A

		EH	IH
NH	Pageviews	0.7581	0.049*
	Submissions	0.728	0.051*
	Posts	0.000*	0.000*
	Activity Time	0.6771	0.281
EH	Pageviews	-	0.067*
	Submissions	-	0.018*
	Posts	-	0.483
	Activity Time	-	0.407

* significant at the 0.1 level

B

	NH	EH	PH	IH
Pageviews	602.46	618.22	536.56	758.83
Submissions	11.88	12.03	11.87	12.74
Posts	0.77	3.59	0.81	2.97
Activity Time (min)	1457.39	1585.95	1517.13	1841.90

Figure 3.3. (A) Z-test (2-tailed) p-values and (B) mean values of the variables measuring behavioural engagement for the different cohorts according to who the students asked for help.

RQ2: To what extent is it possible to identify learners who face problems by looking at their effort before asking for help?

While many learners (n=44) reported in the [Post_Quest] that they could overcome their challenges with some additional effort, most learners (n=54) stated that had put their maximum effort before asking for further help. The early detection of such learners could permit the instructors to prioritise the feedback provision, if needed, to the ones who attempted unsuccessfully to solve their problem. Figure 3.4 presents the behavioural activity of these two cohorts of learners (i.e., the ones who stated they put less effort to overcome a problem before asking for help and the ones who said that they put all the effort needed). We performed a z-test to statistically compare their behaviour. The analysis did not reveal any significant difference regarding the learners' engagement.

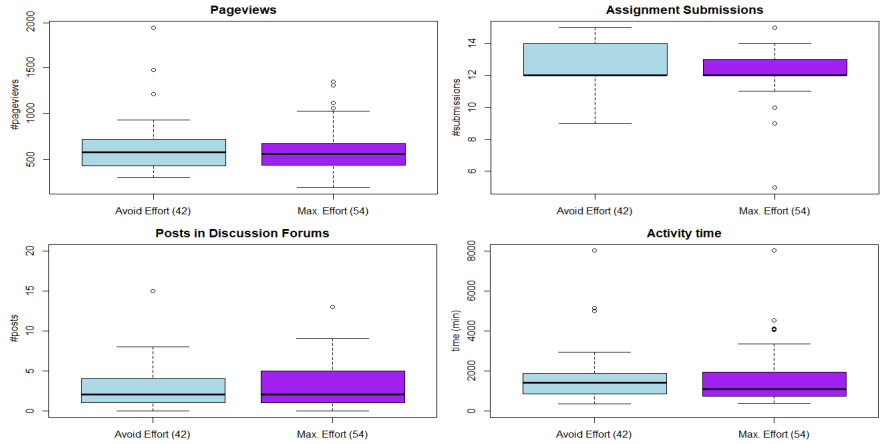


Figure 3.4. Boxplot comparison between the participants who reported they put less effort (Avoid Effort) and the ones put their maximum effort (Max Effort) before asking for support.

RQ3: Is there any kind of common behaviour among the MOOC learners who reported problems before asking for help?

Given the main problems reported by learners in [Exp_1], we chose to focus on learners who faced collaboration problems, since it was the most stated challenge during the course enactment in [Post_ Quest], and on time-related issues, as the most expressed problem in [Priv_ Mess].

Attending to the collaboration issues, we identified common activity patterns among 13 learners facing problems with absent or non-frequently active group members. The common pattern regarded: (a) high number of visits of the general and group forums ([GeneralForum] and [Group_Forum]), (n=12) and (b) posts in both communication forums, starting from the group ones ([Group_Forum]) (n=13). Additionally, two learners, who did not receive any answer from their group members, (c) revisited several times the private messages possibly expecting answers from the course instructor.

With respect to time-related issues, common activity sequences among the learners who sent private messages were not found. Nevertheless, it seems interesting to highlight the case of a learner, who did not receive any answer from the instructor to a question she posed in a private message. After sending the message, the learner kept visiting the private messages for the following two days without doing any other course activity and finally, without receiving any answer, she dropped the course. Figure 3.5 illustrates the activity sequence of that learner within the course, that is the course resources visited before and after sending the private message.

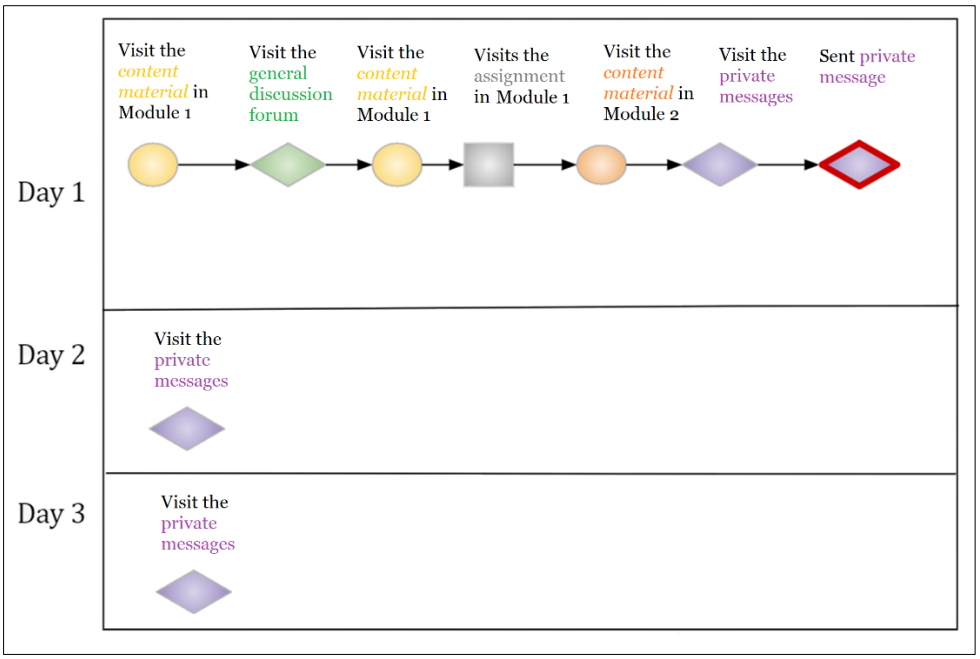


Figure 3.5. Representation of the activity sequence of a MOOC learner within a three-day period.

3.3. Exploratory Study with MOOC Instructors

The third exploratory study (i.e., [Exp_3]) took place from October to December 2018 and consisting of a set of interviews with MOOC instructors. The study aimed at shedding light into MOOC instructors' practices and challenges related to feedback provision during the course enactment. The evidence gathered helped to understand the current needs of MOOC instructors and to collect a set of common learners' problems from instructors' viewpoint.

[Exp_3] involved 14 semi-structured interviews with MOOC instructors (and with other roles of stakeholders who supervise the course design in MOOCs). The interviewees provided contextual information about their background in MOOCs (i.e., previous MOOC experience, number of MOOCs delivered, their role during the course design and enactment). Next, we asked participants about: (a) the most common problems that their learners face, (b) the strategies they employ to deliver feedback, (c) the obstacles they face when providing feedback; and (d) the conceptual and technological tools they would like to have to ease the process of feedback provision. The interviews lasted 1h maximum. Some of them took place face-to-face and some other online to reach the maximum number of participants in the given moment of the thesis.

3.3.1. Overview of the Third Exploratory Study [Exp_3]

The third exploratory study dealt with the following research question: "*What is the participants' perceived experience in the process of providing feedback to learners facing difficulties in MOOCs?".* To better address this topic, we explored the following sub-questions:

- RQ1: What are the most frequent learners' problems given the interviewers' experience as course instructors or TAs?
- RQ2: What strategies do the interviewees employ regarding the provision of feedback to struggling learners?
- RQ3: What are the interviewees' perceptions regarding the challenges they face and the means they would like to have to enhance the process of feedback provision?

Additionally, [Exp_3] explored the differences of the above sub-questions regarding the course topic and discipline. [Exp_3] followed a qualitative phenomenological approach. Creswell & Poth (2017) described as qualitative phenomenological the approach that explores the experiences of different individuals under a concrete situation or phenomenon and their reactions upon such situation or phenomenon.

Regarding the study informants, we followed a purposive sampling method. That is, "*the researchers use their judgement to select a sample that they believe, based on prior information, will provide the data they need*" (Fraenkel et al., 2012, p. 100). As main inclusion criterion we considered participants' compliance with at least one of following roles: (a) MOOC instructors, engaged as designers of the course material and/or as feedback providers during the course enactment, (b) TAs, engaged as facilitators of learners assisting the learners with their problems and doubts. Additionally, we included as informants an Instructional Designer (i.e., in charge of directing MOOC instructors at the design of the course) and a MOOC manager (i.e., in charge of leading technologically and/or pedagogically the MOOC production) considering that given their experience, we could have a wider perspective on the MOOC instructors' problems in design and delivery of feedback. In total we interviewed 14 MOOC stakeholders with teacherly roles (9 male, 5 female), from five different nationalities, with different roles and experiences in MOOCs. From these 14 interviewees, 7 delivered engineering and computer science courses (e.g., programming) and 5 courses under humanities and social sciences topics (e.g., teaching competences for K12). Two interviewees collaborated with instructors delivering MOOCs in both areas. Figure 3.6 portrays the participants' profiling information. According to Trigwell (2000), the chosen informants' size is sufficient enough to guarantee the collection of

rich data and to shed light on the participants' experiences. Regarding the analysis of the findings, we employed content analysis having both etic and emic categories during the coding process (Given, 2012). Two reviewers participated in the coding process. At the beginning of each interview, the participants, informed about study objective, provided their consent on offering their data for research purposes.

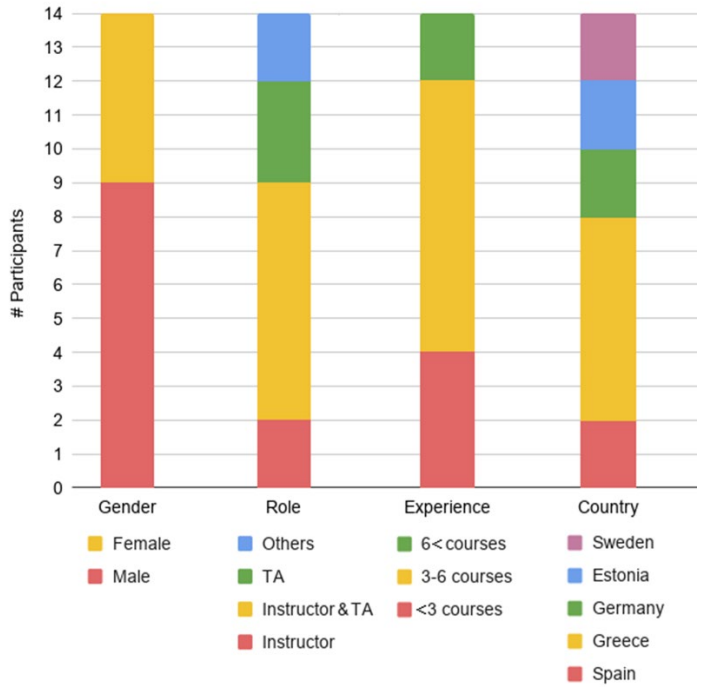


Figure 3.6. Participants' profiling information related to the gender, role, MOOC experience in terms of delivered courses and country. Figure retrieved from Topali et al. (2020).

3.3.2. Results of the Exploratory Study [Exp_3]

As described above, the third exploratory study examined the following research question: "*What is the participants' perceived experience in the process of providing feedback to learners facing difficulties in MOOCs?*". This subsection introduces the findings gathered during [Exp_3], under the three sub-questions presented in Section 3.3.1.

RQ1: What are the most frequent learners' problems given the interviewers' experience as course instructors or TAs?

Interviewees mentioned as most encountered learners' problems in MOOCs the following: the diversity on background knowledge (n=9), time-associated issues (n=8), content-related issues (n=6), the impersonal learner-to-instructor relationship (n=6), the lack of personalised and timely

feedback (n=6), peer and group collaboration problems (n=6), learning design issues (n=5), learners' expectations with the course content (n=4) and technical aspects, such as links that do not work properly (n=4). Participants mentioned common learners' problems despite delivering MOOCs of different disciplines (see Figure 3.7). Table 3.4 depicts indicative excerpts of evidence (see Table 3.4, Learner Problems, A, B, C).

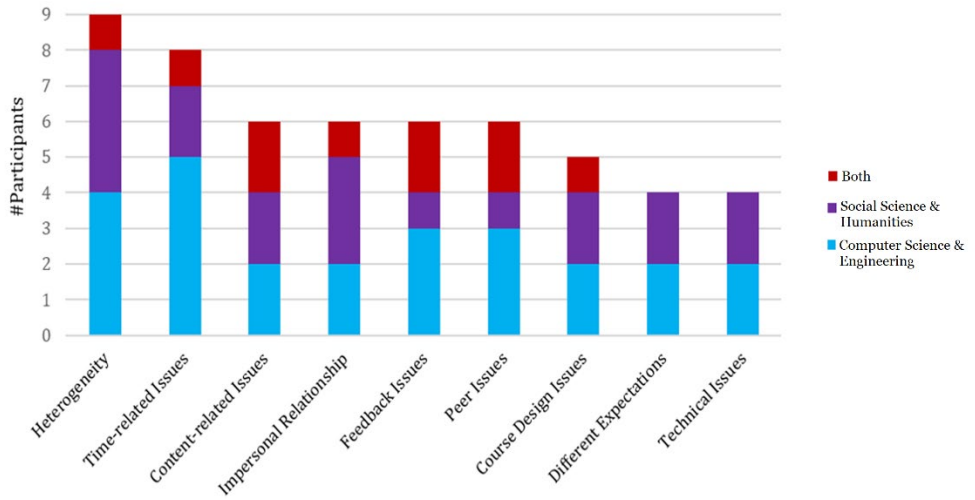


Figure 3.7. Learners' problems as reported by the interviewees with experience in MOOCs of Social Sciences & Humanities, of Computer Science & Engineering and with experience in both fields. Figure retrieved from Topali et al. (2020).

Table 3.4. Selected excerpts of evidence [Exp_3].

Category	Excerpt
Learner Problems	A. *The level of knowledge, the level of comprehension and academic grasp is quite different and usually causes potential problems to learners* B. *We find a lot of academic or content related questions* C. *Another problem is that you (learner) are likely to get inadequate support from teaching staff*
Strategies	A. *We do not use the analytics provided by the platform, because first of all the process is quite slow. Second, we as instructors are not trained well to use them* B. *They provide us with some information which was not learner-centric but video-centric. So, this is not a useful tool for relating the difficulties to the specific learners* C. *We try more or less to reflect [on learner problems]. I mean the more experience we have with designing the more we know what will happen*
Challenges	A. *From my point of view, it (spending a lot of time in forums supporting students) is negative for the teacher because it's quite time-consuming, but on the other hand the results are positive* B. *At some point you see that there are a lot of things depending on you, that you need to run to cover things occurred along the way*
Enhancements	A. *What is missing is that we should have a software that allows you to implement decision-rules. And so that we could put in place specialized triggers and defined rules that will help us track and identify the learners.* B. *I would really need an easy possibility to target certain groups of*

	participants, to have that kind of intelligence selection of participants for example who didn't do the last quiz, A kind of a tool with fine granularity C. *There could be a system, for example as alarm or like a button, within each module, that learners could click it saying, 'I have a problem right now.' That system could give a signal to teachers and so learners could communicate with the course instructors* D. *The tools that we have I think they are sufficient for now. Probably what is missing, I don't know, is that they probably need better guidance to use them*
Comments	A. *I think MOOC instructors need guidance because they are missing things during the course' design* B. *I do not know when the best time is to answer a question, because if you reply soon enough learner loses the satisfaction of trying to solve a problem and if you reply later maybe you will lose the learner*

RQ2:What strategies do the interviewees employ regarding the provision of feedback to struggling learners?

The most frequent reported strategy was the provision of feedback through discussion forums and private messages. Most interviewees stated acting on-the-fly when asked for feedback. Apart from this, 4 interviewees stated that they tried to foresee possible problems and be prepared to act in advance (see Table 3.4, Strategies, C). Yet, one interviewee noted that further guidance is needed even for the a-priori reflection on learners' problems, so that the instructors can be prepared to intervene (see Table 3.4, Comments, A). Out of the 14 interviewees, only 4 of them reported making use of LA tools, e.g., dashboards and charts, to follow the learners' progress and thus anticipate problems and intervene accordingly. Attending to the rest interviewees, when asked about the reasons of not using LA tools, they reported as the main reasons: a) the lack of previous digital skills on how to make sense of the generated information, b) and the fact that LA tools often did not visualise meaningful information, but aggregated data, that could not support actionable interventions (see Table 3.4, Strategies, A, B).

The right timing for delivering feedback was an issue that raised doubts during the interviews. A TA, for example, mentioned that he did not receive clear directions on the timing to provide feedback (see Table 3.4, Comments, B). All the interviewees based their intervention timing on the type of the reported problem. That is, technical problems were addressed immediately, with content-understanding issues to be the second type of problem that instructors tended to solve when no peers responded.

RQ3: What challenges do the interviewees usually face and with which means they would like to enhance the process of feedback provision?

Figure 3.8 illustrates the MOOC instructors' challenges related to the provision of feedback to learners. Most of the interviewees (n=12) reported the workload and the course management as the main obstacle to address the

learners' needs (see Table 3.4, Challenges, B). One instructor declared as time-consuming the personalised support of learners, despite the positive outcomes (see Table 3.4, Challenges, A).

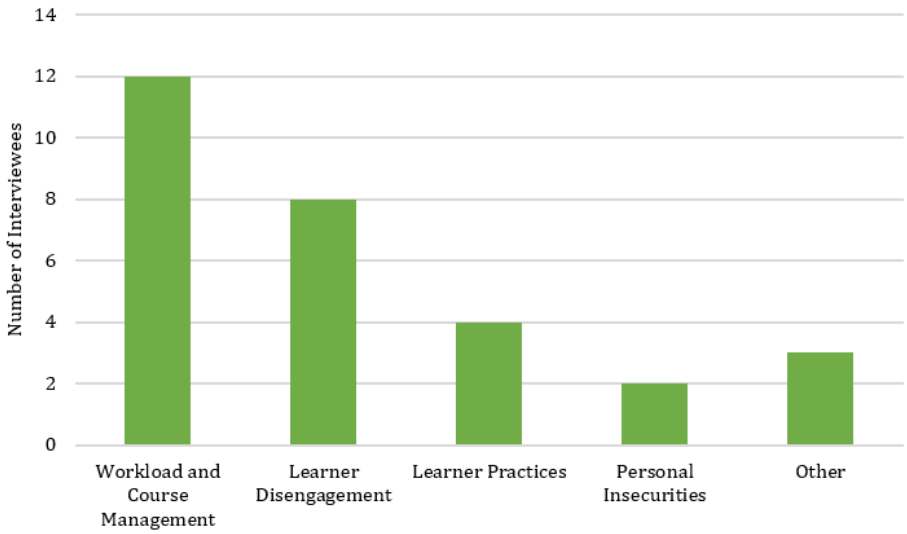


Figure 3.8. Challenges of MOOC instructors. Figure is adapted from Topali et al. (2020)

To overcome their challenges and to provide personalised feedback, n=10 interviewees suggested the creation of tools that could alert them when learners are struggling, and tools that they could finetune with if-then rules to target specific learner cohorts (see Table 3.4, Enhancements, A, B). One interviewee emphasised the need of further guidance and training, so that the MOOC teaching teams can understand and use the LA tools (see Table 3.4, Enhancements, D). Finally, n=4 interviewees mentioned the need of tools to enhance learner-to-instructor communication and to facilitate the feedback provision beyond discussion forums (see Table 3.4, Enhancements, C).

3.4. Discussion

The three exploratory studies presented above helped us to: (a) understand and collect a set the learners' problems that commonly occur at MOOC enactment, as reported by learners and instructors, (b) explore different help-seeking behaviours of struggling learners and, (c) uncover the instructors' strategies and challenges related to the provision of feedback in MOOCs.

The analysis of the evidence gathered, indicated several common problems that learners can experience during learning in MOOCs, such as difficulties due to the background knowledge, time-associated restrictions, content and activity related issues, the loose learner-to-instructor relationship

and lack of timely feedback. Our findings from [Exp_1] and [Exp_3] agree with previous works of Gütl et al. (2014), Henderikx et al. (2018), Hone & El Said (2016) and Loizzo et al (2017). Additionally, the fact that [Exp_3] did not reveal differences among the learners' problems based on the course discipline shows that there are some core learners' problems commonly shared in MOOCs, although they may be more frequent in some MOOCs depending on the course topic. For example, lack of timely feedback and collaboration problems with peers were mentioned as challenges more by Computer Science MOOC instructors (n=3) than Social Science ones (n=1) (see Figure 3.7). Building on that finding, we consider that providing MOOC instructors with a set of learners' problems during the course design could facilitate the reflection on potential learners' challenges and thus could permit a better preparation on personalised interventions.

Another interesting topic to take into account, regards the analysis of the learner patterns when facing problems. Various studies in the literature, such as the one of Henrie et al. (2015), apply several metrics, like the ones used in our study (i.e., posts in discussion forums, time spent, pageviews and assignments' submission) to predict, for instance, learners at risk of dropping out. In our case, [Exp_2] indicated that the learner activity did not support the distinction between cohorts of learners who devoted effort to overcome their problems from the ones who did not. Consequently, it is possible that an automatic tool which is based merely on learners' behaviour to be less effective. This finding is aligned with instructors' statements in [Exp_3], that often LA-tools are not useful during the course enactment, because they monitor and deliver aggregated data that is less relevant for the course instructors. Further work is needed to explore if by involving the instructors in the selection of indicators that can define when a learner is struggling could lead to more informative results. Under that prism, the works of Pardo et al (2018) and Liu (2017) proposed the use of LA tools which permit to course instructors to finetune the metrics that are relevant for them to provide feedback to their learners.

Moreover, according to the findings of [Exp_3], there is a lack of background knowledge on behalf of MOOC instructors to understand LA information and a lack of tools to guide instructors in an a priori reflection on learners' problems. This finding is in accordance with the works of Fernández-Nieto et al. (2022), Matcha et al. (2020) and Rienties et al. (2018), that highlighted the difficulties of both learners and instructors in interpreting the LA data. Additionally, Mangaroska & Giannakos (2019) suggested the need of frameworks and tools to help instructors in understanding and applying the LA information and connected to with the course LD.

Given the above finding, we considered essential to explore the current LA tools aimed to monitor learners' behaviours and shape feedback in MOOCs and the extent to which they involve MOOC instructors in such process. Do the LA tools guide the users (in our case the MOOC instructors) on how to use and understand the LA data? Do the LA tools permit flexible options for customizing the visualisations related to the provision of personalised feedback (e.g., configuring the triggers based on learners' activity, designing and deliver semi-automated feedback for concrete learner cohorts)? The next chapter sheds light into these questions under #OBJ_1, i.e., *to understand the current state of instructor-led LA-informed feedback in MOOCs*. Our interpretation of the findings in [Exp_3] also motivated a proposal on how to support MOOC instructors to shape personalised and contextualised feedback interventions at their courses, related to #OBJ_2. We found the need of a conceptual framework, that will support instructors to reflect on expected learners' problems and to design personalised feedback to address concrete learners' problems (see Chapter 5).

3.5. Conclusions

This chapter discussed the three exploratory studies carried out at the first DBR cycle. The presented studies (i.e., [Exp_1], [Exp_2], [Exp_3]) targeted the main MOOCs stakeholders, i.e., the course learners and the course instructors. The analysis of the studies provided evidence about: a) the learners' challenges during the course enactment, b) learners' help-seeking behaviours in MOOCs and c) current practices and limitations of MOOC instructors in relation to the design and provision of personalised feedback.

As stated above, this exploratory work generated the requirements for the proposed solutions under the thesis objectives #OBJ_1 (i.e., a systematic literature review that uncovers the current state of instructor-led LA-informed feedback in MOOCs) and #OBJ_2 (i.e., a conceptual framework aimed at helping MOOC instructors to shape personalised and contextualised feedback interventions). Specifically, the findings of [Exp_3] indicated the need for LA tools that support automated or semi-automated instructor-led feedback interventions in MOOCs (see Chapter 4). A systematic literature review on the topic could provide insights about the current LA -informed strategies, their impact on MOOC instructors and learners and their limitations. The finding from [Exp_3] on targeting concrete learner cohorts and on prioritising their feedback interventions according to the learners' problems inspired the proposal of the FeeD4Mi process (contribution #CON_2(a)) (see Section 5.3.2) that aims to direct the instructors in the design of feedback targeted to specific learners. Additionally, the findings from the three exploratory studies informed

the FeeD4Mi catalogues (contribution #CON_2(b)) (see Section 5.3.3) that aims at providing suggestions to facilitate the design of personalised feedback strategies. Moreover, the finding from [Exp_3] about the need of providing semi-automatic feedback, led to reflect on the need of designing a tool that could support computer-interpretable designs and automatize the feedback procedure (contribution #CON_2(d)) (see Section 5.5).

Chapter four

LA-Informed Feedback In MOOCs: A Systematic Literature Review

Summary: The exploratory work presented in Chapter 3 uncovered instructors' difficulties with LA tools both in understanding the data provided and in designing and automatizing feedback for specific learner cohorts. Additionally, as presented in Chapters 1 and 2, several researchers, such as Jivet et al. (2017) and Matcha et al. (2020), explored systematically LA tools applied in higher education and found that these tools frequently lack course contextualisation and pedagogical grounding, a fact that could hinder the benefits of LA-informed interventions. Therefore, it seems essential to shed light on existing LA tools for delivering and/or informing feedback interventions in MOOCs (i.e., #OBJ_1). Given the lack of such a review in MOOCs, this chapter reports a **systematic literature review** discussing the use of LA tools for automatic or semi-automatic instructor-led feedback in the massive contexts (i.e., #CON_1). Results showed an interest over time on using LA for generating and shaping feedback in MOOCs. Nevertheless, the findings support: a) t**he lack of empirical studies** evaluating the effect of the LA-informed feedback on learners, b) the **lack** of **pedagogical underpinning** of the LA tools for feedback, and c) the l**ack of guidance** on users to understand and apply the LA generated information. Finally, this chapter discusses such implications for the instructor-led feedback in MOOCs.

This Chapter is based on the following publications:

Topali, P., Chounta I. A., Martínez-Monés, A., Dimitriadis, Y. (2022). Delving into Instructor-led Feedback Interventions Informed by Learning Analytics in MOOCs. *Under Review*

4.1. Introduction

LA aims at enhancing learning and teaching processes in technology-supported environments by analysing learners' activity (Gašević, Dawson, & Siemens, 2015). One of the research focus of LA methods is to inform and scale feedback interventions (Lim et al., 2021). Several systematic literature reviews discussed the potential of LA tools to support timely and personalised feedback interventions in the context of higher education and online learning.

For instance, Avella et al. (2016), Chiappe & Rodríguez (2017) and Banihashem et al. (2018) explored systematically the use and the challenges of LA in the educational landscape. The aforementioned research works stressed the added value of LA in reshaping feedback processes regarding the aspects of personalisation and timing. Yet, Avella et al. (2016) criticised the lack of contextualisation under the course design that often accompanies several LA tools. The authors proposed the inclusion of the educational stakeholders in the design and consideration of LA information for more contextualised feedback. Similarly, Chiappe & Rodríguez (2017) highlighted that the contextualised pedagogical features should accompany LAs to facilitate well-informed decision making.

Schwendimann et al. (2017) and Matcha et al. (2020) reviewed systematically the uses of LA-dashboards. Matcha et al. (2020) systematically explored the use of LA dashboards as a form of feedback supporting learners' self-regulation. According to the results, the information provided by the retrieved dashboards, which regarded visualisation of aggregated data or logs without course contextualisation, was not always informative enough for the learners. Schwendimann et al. (2017) highlighted the lack of alignment among the visualised data and the happenings of learning that might impede effective in supporting actions for learners and instructors. Focusing on MOOCs, Sunar et al. (2016) conducted a systematic literature review exploring personalisation and adaptation in MOOCs. This systematic literature review showed the interest in attracting the provision of personalised feedback in massive learning contexts. The authors highlighted the potential of LA tools in enabling targeted interventions and further enhancing the course quality. A recent systematic literature review by Cavalcanti et al. (2021) explored automatic feedback in online learning environments. The findings highlighted the lack of educational research to inform the design of tools for automatic feedback and the special attention paid to students and not to teachers, who are the ones shaping the feedback practices.

Despite the informative findings about LA-informed feedback, the studies mentioned above do not discuss automatic or semi-automatic LA-informed

practices regarding the design, use, and evaluation of feedback interventions in MOOCs and do not focus explicitly on the course instructors as the feedback providers. Therefore, a review of LA initiatives informing instructor-led feedback interventions could help to understand how feedback practices are implemented in MOOCs and which their limitations are. Accordingly, the current chapter presents a systematic literature review to understand the state of the art of instructor-led LA-informed feedback interventions in MOOCs. Instructor-led LA-informed feedback considered interventions delivered by the instructors after they are supported by LA. Additionally, it considers interventions delivered automatically by LA tools, where instructors intervene either a priori by designing feedback aspects or on-the-fly by approving LA-informed feedback decisions during the course enactment (see Figure 4.1).

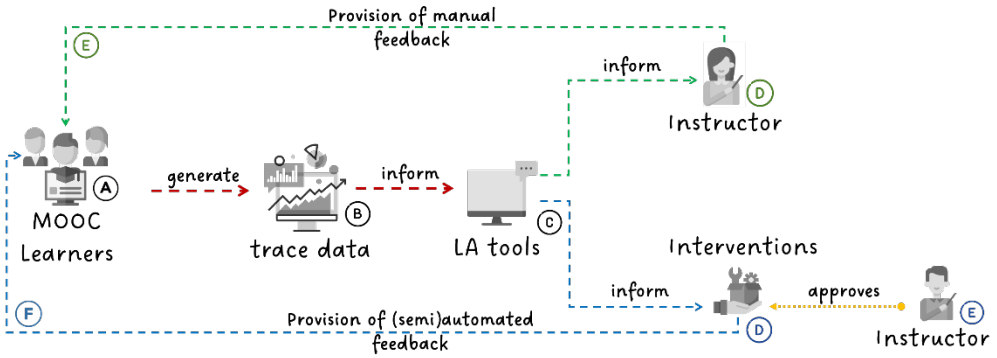


Figure 4.1. Overview of the process of instructor-led LA-informed feedback in MOOCs.

By understanding the current state of instructor-led feedback and the ways it is designed and delivered in MOOCs, we will attain the first research objective (see Figure 4.2). The rest of this chapter is organised as follows. Sections 4.2 and 4.3 present the research questions guiding this systematic literature review and its methodology, respectively. Section 4.4 illustrates the results. Section 4.5 discusses the outcomes obtained. Finally, Section 4.6 provides the conclusions of the chapter.

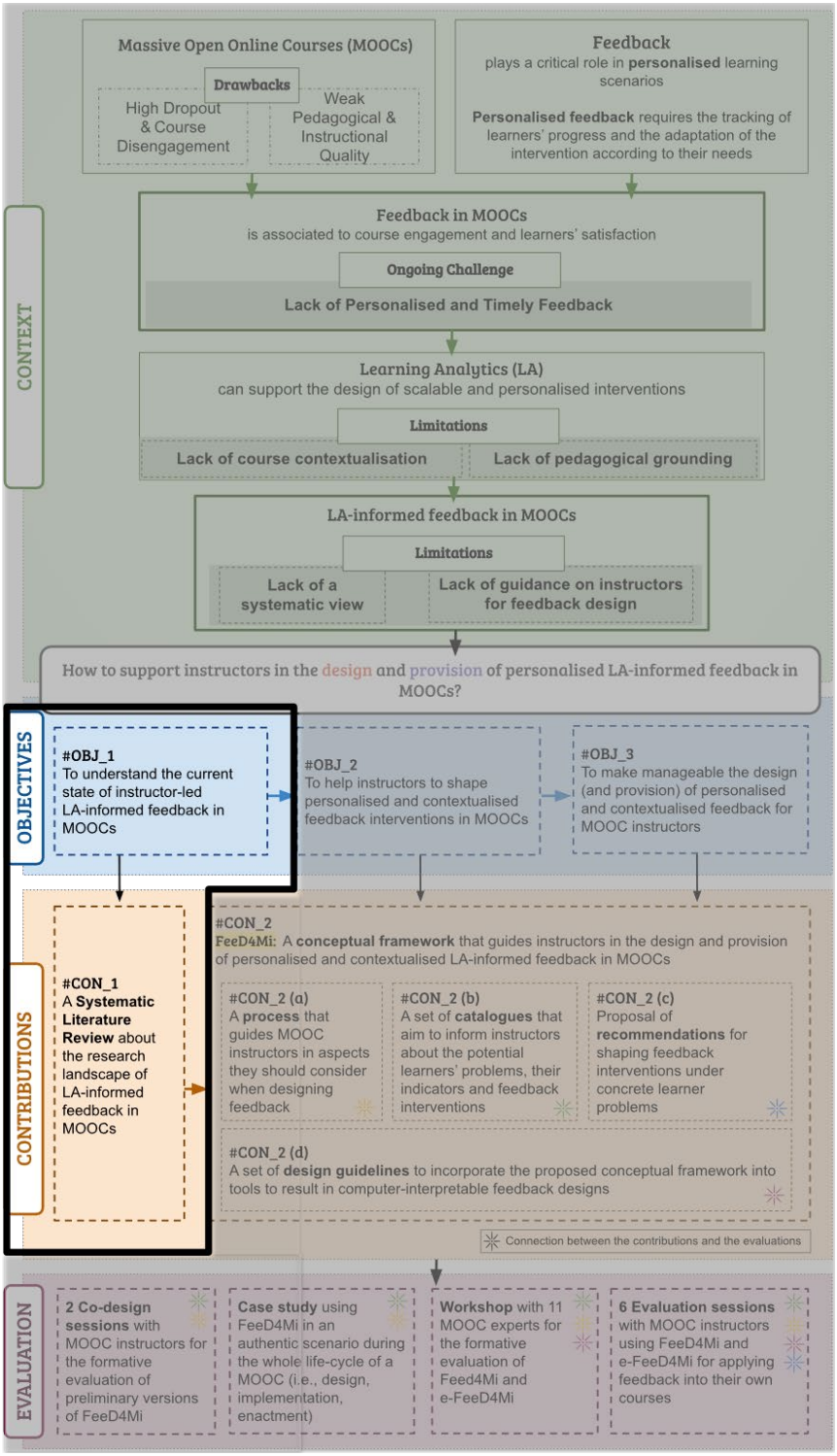


Figure 4.2. Overview of the objective and contribution addressed in Chapter 4.

4.2. Research Questions

Driven by the findings reported in [Exp_3] (see Section 3.3) and the gaps of prior reviews on instructor-led LA-informed feedback interventions (presented in 4.1), this systematic literature review aims to address the following research question (RQ): ***What is the current landscape on the provision of instructor-led LA-informed feedback in MOOCs?*** To better answer the stated RQ, we followed an anticipatory data reduction process (Miles & Huberman, 1994); we identified four sub-questions and further divided them into 11 concrete informative questions (IQ) (see Figure 4.3). Specifically, we explore:

- ***RQ1: What is the overall research state of the LA-informed feedback in MOOCs?*** This question will give an overview of the reviewed contributions in terms of publication trends: years, venues (i.e., conferences, journal, and contribution type) (see I.Q.1.1 and I.Q.1.2). Such classifications may be valuable for MOOC researchers and designers to summarize and classify all existing publications about LA tools (e.g., publishing forums, types of studies).
- ***RQ2: How is feedback designed in MOOCs in terms of the pedagogical theories followed?*** This RQ aims to explore the extent to which the reviewed LA tools follow a pedagogical theory to guide the design of the feedback interventions in MOOCs (I.Q.2.1), the feedback purpose (I.Q.2.2) and the course learning context (i.e., MOOC platform, course discipline, cohort of targeted learners) (I.Q.2.3). Regarding I.Q.2.2, previous researchers on feedback, such Dawson et al. (2019), Hattie & Timperley (2007) and Henderson et al. (2019) proposed various purposes that feedback interventions can satisfy. The current systematic literature review follows the taxonomy by Henderson et al. (2019) for the analysis of the findings.
- ***RQ3: How is LA applied in MOOCs to result in relevant information for feedback?*** Personalised feedback requires a follow up on learners' progress (or other individual characteristics of learners) collecting information from various sources to shape targeted interventions (Maier & Klotz, 2022). Thus, this RQ focuses on the learners' data collected to inform LA-based feedback (I.Q.3.1), the computational methods applied to analyse such data (I.Q.3.2) and the ways the feedback information is delivered (I.Q.3.3). We consider that the synthesis of such evidence might be relevant for MOOC researchers and tool designers because it aims to provide the commonly applied indicators to generate feedback information based on learners' behaviours.

– ***RQ4: What are the reported effects of the instructor-led LA-informed feedback interventions in MOOCs?*** According to Tsai & Gasevic (2017), there is a scarcity of empirical studies related to LA interventions in Higher Education. To that end, this RQ aims to provide evidence regarding the effects of the proposed feedback on learners (I.Q.4.1), the evaluation of the proposed feedback interventions (I.Q.4.2), and the assessment of the LA tools (I.Q.4.3).

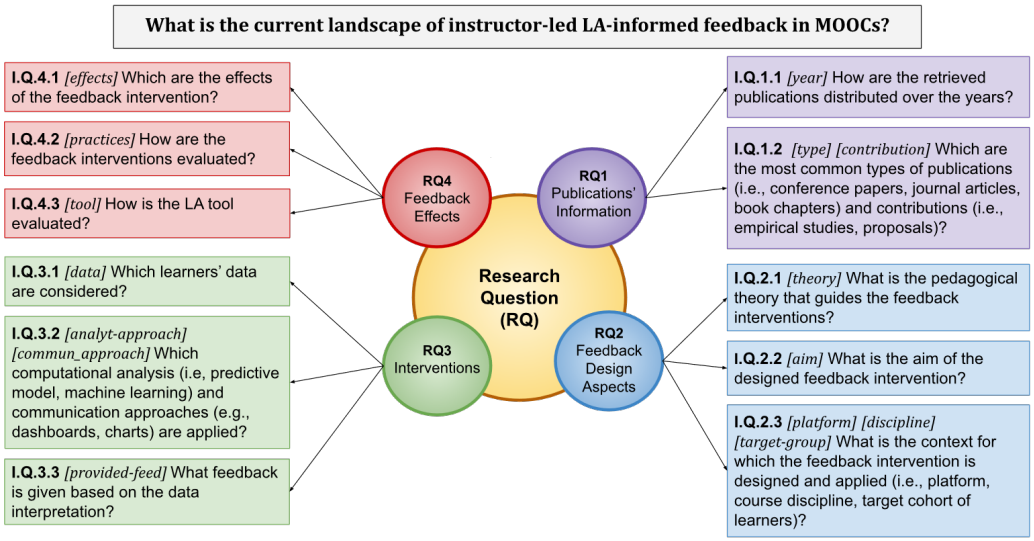


Figure 4.3. Anticipatory data reduction schema including the RQs, the four sub-questions (circles) and informative questions (rectangles) guiding the systematic literature review.

4.3. Methodology

This systematic literature review followed the methodological guidelines proposed by Kitchenham & Chartes (2007), which are regularly used in the TEL research field. Kitchenham & Charters structure the systematic literature review process under 3 phases, i.e., planning the review, conducting the review and reporting the results (2007). Table 4.1. summarises the decisions taken during the first phase of review planning.

Table 4.1. Decisions taken during the systematic literature review planning phase.

Review Aspects	Decision	Reasoning
Digital Libraries	ACM Digital Library (Guide to Computing Literature), IEEE Xplore Digital Library, ScienceDirect, Scopus and Web of Science	We considered these databases as the most relevant ones covering a high number of the contributions in TEL, according to previous related works (Alonso-Mencía et al., 2020; Cavalcanti et al., 2021).
Search	MOOC* OR "Massive Open Online	The terms *MOOC* OR "Massive Open*

String	Course*" **AND** feedback OR scaffolding OR assistance OR support **AND** tutor* OR teach* OR instructor* OR practitioner* **AND** "Learning Analytics" OR "data driven" OR "evidence based"	*Online Course*"* refer to the learning context we focus. The terms *"feedback OR scaffolding OR assistance OR support"* often complement each other when describing the feedback process (see Economides & Perifanou (2018) and Konert et. al (2016)). The terms *"tutor* OR teach* OR instructor* OR practitioner*"* describe instructor-led actions and have been mentioned in previous works (Brouns et al., 2014; Dabbebi, Iksal, Gilliot, May, & Garlatti, 2017; De Notaris, 2019; Gil-Jaurena & Domínguez, 2018; Haavind & Sistek-Chandler, 2015). The terms *"learning analytics" OR "data driven" OR "evidence based"* are used as synonyms for defining learning analytics in previous works (see Mangaroska & Giannakos (2019) and Meleg & Vas, (2020)).
Search Location	Title, abstract and keywords (abstract if restriction)	We believe that the selected sections are ones that most likely contain representative information on the topic.
Time Restriction	From 2010 to April 2022	The search phase spanned from 2010 to 2022, thus covering all related publications from the beginning of research in MOOCs until the submission of this manuscript.
Screening	*First Screening*: reading Abstract-Title-keywords *Second Screening*: reading the sections of Introduction and Discussion *Third Screening*: reading the whole paper	We deem that publications about LA-informed feedback in MOOCs will summarise their main contributions in the title and abstract, and further details in introduction and discussion section. Therefore, these sections provide enough information to apply the inclusion and exclusion criteria. When having the last pool of papers, we read the whole manuscript to assure its relevance with the systematic literature review topic.
Inclusion Criteria	✓ Design of feedback interventions to deliver support to learners ✓ Use of LA to identify when/what/how to offer support (data-driven decision making) ✓ Evaluation of instructor-led LA-based feedback interventions	We consider in scope all the publications dealing with the design and provision of instructor-led LA-informed feedback in MOOCs targeting learners.
Exclusion	× Duplicate reports	Publications describing other purposes

Criteria	× Secondary and tertiary studies (e.g., Systematic literature reviews) × Abstracts × Papers written in other languages than English × Publications dealing with the topics resented in the inclusion criteria without involving MOOCs	than LA-informed feedback in MOOCs are out of the scope of this analysis.

From an initial pool of 227 papers given the applied search strings, and after performing the two screenings considering the inclusion and exclusion criteria, we came across with 56 papers. We included 12 additional papers, not published in the selected digital libraries but cited in the included papers (snowball references). Finally, and after a last screening, we considered as relevant a total number of 38 research publications. Figure 4.4 shows the overview of the analysis process.

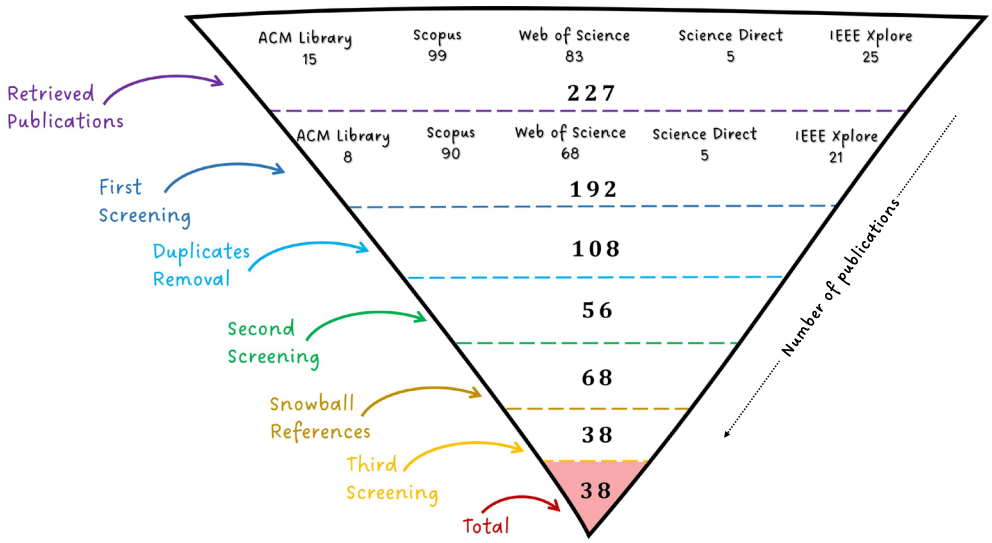


Figure 4.4. Overview of the systematic literature review process followed.

4.4. Results

This section presents the results alongside with the four RQs. The list of these papers is presented in Appendix B, Table B.1). This table includes the employed paper ID as a label in the figures and tables of the following sections to reference the papers for simplicity.

4.4.1. RQ1: Publications' Information

We analysed the papers based on the year of publication, the publication type, and the contribution type (see Figure 4.5). According to the results, the first publication about LA-informed feedback in MOOCs was in 2014. Although instances of MOOCs exist since 2008, we hypothesize that our results started in 2014, because MOOC platforms began to offer courses systematically from 2012 and on (Moe, 2015). An increased interest in the topic was noted between 2015 and 2018, with a peak in 2017 (N=7). In 2019, the number of publications decreased significantly. However, in 2020 and 2021 (N=7 and N=6, respectively) the attention on LA-informed feedback in MOOCs was raised again.

Most of the papers were published in conference proceedings (n=26), with fewer journal publications (n=10) and book chapters (n=2). Nonetheless, journal publications increased from 2018 on. Typical venues for the published papers regarded conferences such as LAK[6] (n=4), L@S[7] (n=3), CSCL[8] (n=2) and others such as TEEM[9], LWMOOCS[10], ICICI[11], IEEE TALE and ICALT[12].

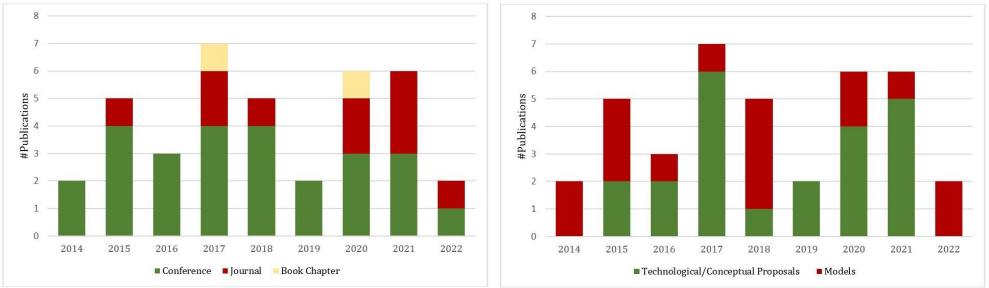


Figure 4.5. Left: Publications attending to the year of publication and publication type. Right: Publications attending to the year of publication and contribution type.

Proposals of system prototypes and conceptual tools (e.g., frameworks) were the most frequent types of contributions (n=22), followed by computational models, such as predictive or network analysis ones (n=16). Only four (4) papers presented empirical studies performed in real MOOC environments (Cobos & Ruiz-Garcia, 2020; Ferschke et al., 2015; Teusner et al.,

6 Learning Analytics & Knowledge
7 Learning at Scale
8 Computer Supported Collaborative Learning
9 Technological Ecosystems for Enhancing Multiculturality
10 Learning with MOOCs
11 International Conference on Intelligent Data Communication Technologies and Internet of Things
12 IEEE International Conference on Advanced Learning Technologies

2018; Tomar, Sankaranarayanan, Wang, & Rose, 2017). This data shows an interest in LA systems and models that may generate and manage feedback. Considering the growth of the MOOC movement along with the plethora of MOOC platforms and providers, our findings suggest that there is an interest in providing systems and conceptual proposals to inform the design of tools. However, this interest is still at an early stage, since no empirical evidence is reported.

4.4.2. RQ2: Feedback Design Aspects

Concerning I.Q.2.1, from the 38 papers retrieved, only 8 of them define a theory that informs the proposed feedback interventions. Konert et al. (2016) and Rohloff et al. (2019) follow Self-Regulated Learning as the theoretical basis for the development of LA dashboards to support course participants. The work from Sharma et al. (2020) draws on the Cognitive Theory of Multimedia Learning by Mayer & Moreno (2003). Sharma et al. (2020) used Multimedia Learning Cognitive Theory to support the use of eye-tracking for analysis of videos for facilitating learning. The work of van den Beemt et al. (2018) is motivated by Cognitive Constructivism (Bruner & Duhl, 1966) focusing on knowledge building based mainly on learner-to-learning material interaction. Ferschke et al. (2015) and Tomar et al. (2017) use Collaborative Learning as the basis for designing peer support. Yilmaz (2021) proposed a tutoring system where scaffolding is shaped according to the theoretical basis of the Dynamic/interactive Assessment approach (DA). DA is an assessment process grounded in Vygotsky's Zone of Proximal Development (Tzuriel, 2000). Finally, Frick et al. (2022) discusses the use of the First Principles of Instruction (Merrill, 2002) to guide the design of tailored feedback to learners based on their progress.

Regarding I.Q.2.2, results revealed various purposes of the LA-informed feedback interventions. We associated the findings with the five categories of feedback impact proposed by Henderson et al. (2019): (a) learning outcomes (i.e., learners' progress and performance), (b) cognitive aspects (i.e., understanding of a skill, self-regulation), (c) affective/motivational aspects (i.e., aspects related with negative-positive emotions, etc.), (d) relational aspects (i.e., the relationship between the instructor and the learner), (e) values, beliefs and identity (i.e., serving the social theory of learning, boosting socialisation). Figure 4.6 presents the various purposes of feedback, as mentioned at the reviewed papers, and connected to the categories by Henderson et al. (2019). We have associated the relational purpose of feedback with instructors' active presence in giving timely and individualised support tailored to learners' needs.

Most of the studies (n=17) intended to promote awareness about learners' progress and course behaviour. Ruiz et al. (2014) proposed an LA visualisation aiming at generating feedback information easily and effortlessly to help instructors to shape interventions. Several researchers motivated their studies by highlighting instructors' difficulties in delivering feedback adapted to the learners' needs. Their contributions focus on tools delivering personalised and timely support (n=14). Fewer studies (n=4) explored community building via enhancing message exchange. 25 publications aimed at providing support to instructors by generating information about learners' progress, so they can later deliver feedback interventions. 23 studies regarded automated feedback interventions delivered directly to learners. Nevertheless, in these cases, the instructor is expected to participate at the design or approval of the feedback interventions. For instance, Karaoğlan-Yılmaz et al. (2021) and Reza et al. (2021) propose automated feedback interventions, while the conditions that trigger the feedback are decided by the course instructors a priori during the course design. Finally, 6 contributions addressed both course stakeholders (i.e., learners and instructors) either in delivering direct feedback to learners or highlighting critical learner behaviours to instructors.

Attending to I.Q.2.3, most of the publications (n=22) focused on shaping feedback interventions for all participants without targeting a specific cohort. 12 publications focused on learners at risk of dropping out. Xing and Du (2018) proposed a predictive model to support MOOC instructors in prioritising and delivering feedback to learners with a high dropout risk. Vinker and Rubinstein (2022) suggested visualisations of learners' submission trajectories to reveal disengaged learners and alert instructors. Few studies (n=4) specified more their target cohort. Teusner et al. (2018) focused on 'struggling learners' (i.e., learners with problems in the programming activities) and Sharma et al. (2016; 2020) targeted learners with low attention and concentration during the course run-time. Du et al. (2018) proposed a LA tool for feedback interventions for learner cohorts that behave differently from the norm.

Regarding the context in which the LA solutions are designed and applied, the MOOC platform itself is of great importance, since it captures the learners' trace data. Most of the interventions were proposed, designed, and implemented in platforms of the popular MOOC providers, such as Coursera, Canvas, Open EdX. Out of the 38 studies, 7 interventions were created for Open EdX, 6 for Coursera and 2 for courses in Canvas Network. Other platforms were Open HPI, NextThought platform, Iversity and XuetangX platform, Moodle, and other institutional platforms. In 11 publications, the course delivery platforms were not defined, either because the study was not empirical or because the developed technological tool for feedback was not platform dependent.

Paper ID	Feedback about learning outcomes		Cognitive Feedback		Affective Feedback	Relational Feedback	Feedback changing values
	Increase awareness	*Improve Retention*	*Support learning*	*Boost SRL*	*Stimulate motivation*	*Provide person. feedback*	*Promote message exchange*
1						●	
2			●		●		
3	●☺						
4	●☺						
5		●					●
6						●	
7	●☺						
8						●	
9							☺
10		☺					
11	●						
12				☺			
13		●			●	●	
14						●	
15	●						
16	●					●	
17			●				
18	●						
19						●	
20				☺			
21	●☺						
22	●☺						
23	●☺						
24			☺		☺		
25	☺				☺	☺	
26						☺	
27	☺	☺	☺				☺
28		☺					☺
29		☺					
30	●						☺
31							
32	●						
33	●	●				●	
34						☺	
35	☺					●	
36	☺						
37		☺				●	
38			●				

Figure 4.6. Purposes of LA-informed feedback in MOOCs.
Feedback agents: ☺-LA tools, ●-Instructors. See Paper ID in Appendix B.1.

Figure 4.7 displays the distribution of the publications over the five academic disciplines according to Wu et al. (2012): Humanities, Social Sciences, Natural Sciences, Formal Sciences, and Applied Sciences. Most of the studies regarded Formal Sciences (i.e., Programming, Mathematics). Many studies were related to Applied Sciences (i.e., Engineering and Technology) and Humanities (i.e., Education, Languages and Philosophy). Finally, 6 publications did not define the academic area where their proposal applied or aimed to be applied.

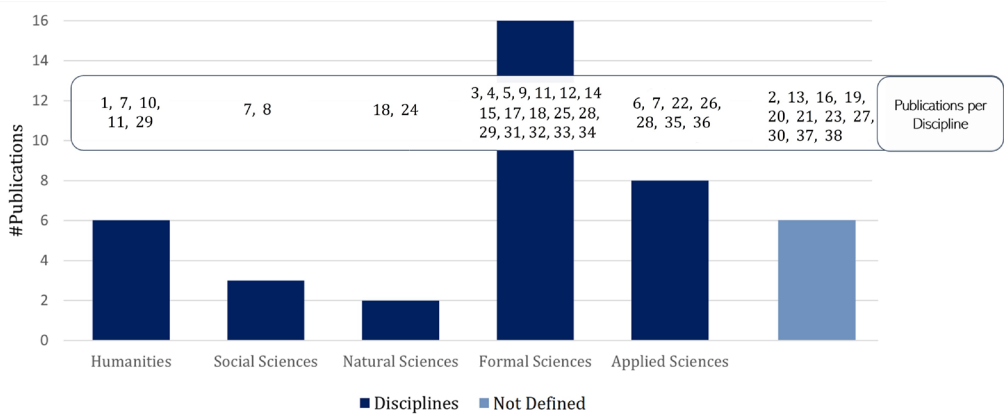


Figure 4.7. Distribution of the studies over the five thematic areas. See Paper ID in Appendix B.1.

4.4.3. RQ3: Implementation of the Proposed Intervention

Answering I.Q.3.1, Table 4.2 indicates the log data collected for informing LA-based interventions. The main data source was clickstream data from platform logs, occasionally accompanied by self-reported data. Most studies relied on data provided by interactions in forums, and other MOOC-related aspects (answering quizzes, watching videos, etc.) Many research works captured learner activity in forums regarding post creation (i.e., posts entries and post replies) and views of other posts (n=19). Few studies captured further information, such as positive and negative votes on the forum posts (Klusener & Fortenbacher, 2015), initiation of threads and sub-threads and posts' density and length (Crossley, Dascalu, McNamara, Baker, & Trausan-Matu, 2017). Furthermore, the reviewed works used data from course assignments (e.g., scores or number of passed quizzes, and tests), «honour» marked assignments (i.e., the highest marks achieved at a course task), failed tasks, video activity (e.g., video replays). Malekian et al. (2020) and Thankachan (2017) explored the impact of the sequence on the learners' activities, by checking their progress in terms of repetition of wrong answers in submitted quizzes and scores of past activities. A less frequent source of data regarded learners' information from surveys (e.g., previous knowledge level, demographic

information, learners' goals, objectives and expectations) (Cobos & Ruiz-Garcia, 2020; Cobos & Soberón, 2020; Du et al., 2018; Sharma et al., 2016; Singelmann, Swartz, Pearson, Striker, & Vazquez, 2019; Smith, 2015).

Table 4.2. Summary of the log data reported in the reviewed papers. See Paper ID in Appendix B.1.

Learners' Data Gathered	Studies
General course activity	
Course Logins/ Logouts (sessions registered, days connected, inactive days)	3, 4, 13, 15, 16, 18, 22, 32, 36
Time spent in course pages and resources	3, 4, 7, 10, 12, 15, 16, 20, 21, 23, 30
View of course material	1, 7, 17, 20, 32, 36
Number of lectures downloaded	17
Forum activity	
Learners' forum activity (e.g., questions posted, answers)	1, 3, 4, 5, 8, 9, 11, 13, 17, 20, 23, 28, 30, 31, 32, 35, 36
Up- and down-votes given-received	11
Posts' length	5, 11
Posts' content	5, 8, 9, 15, 27
Entry in forums without further action	18
Submission activity	
Scores	3, 4, 6, 10, 15, 16, 18, 19, 20, 21, 22, 23, 28, 30, 32, 33, 34, 35, 36, 38
Time spent on quizzes	3, 4, 15, 16, 18, 19, 20, 21, 22, 29, 30, 33, 38
Number of submissions	7, 13, 15, 16, 20, 21, 22, 32, 33, 38
Number of failed-passed submissions	3, 4, 15, 17, 21, 22, 33, 34, 38
Number of previous failed submissions	17, 30, 33
Number of "honor-marked" submissions	5, 21, 22
Sequential data-submissions	15, 17
Assignment attempts	4, 15, 18, 20, 33
Hints used	16, 30
Submission length	8
Video activity	
Video time spent	15, 16, 21, 22, 38
Proportion of finished videos	15, 38
Repeated video	16, 21, 22
Video events (e.g., pause forwarding)	15, 16, 21, 22, 31, 38
Eye tracking logs (student gaze)	24, 25
Number of emails sent	13

Attending to IQ.3.2, the most frequent computational approaches applied were machine learning and process mining techniques (n=25), especially predictive modelling (n=8). Xing et al. (2016) and Xing & Du (2018) proposed temporal predictive models that prioritised learners at risk of dropping out. Du et al. (2018) employed the framework of Exceptional Model Mining (EMM) to detect 'exceptional' learner behaviours, i.e., learner patterns that may require

the instructors' attention. Sharma et al. (2016, 2020) used multi-modal LA for eye-tracking analysis aiming at capturing indicators of learners' performance to give feedback to learners about their reading behaviour and to course instructors about learners' attention. 13 studies did not specify the analytical approach to inform feedback interventions.

Figure 4.8 shows the relationship between the LA techniques proposed/applied and the feedback purposes (IQ.3.3). All publications highlighted the contribution of LA as a way of providing timely and personalised feedback. Nevertheless, out of the 38 publications, 14 of them did not specify the type of feedback practices. In the rest of the studies, we meet 12 studies discussing implicit feedback through visual aids and 13 studies proposing textual feedback for supporting participants' awareness, promoting Self-Regulated Learning, improving course retention, and stimulating learners' motivation. Dashboards were the main means of visual feedback (Eradze & Tammets, 2017; Konert et al., 2016; Rohloff et al., 2019; Ruiperez-Valiente, Munoz-Merino, Gascon-Pinedo, & Kloos, 2017; Ruipérez-Valiente, Muñoz-Merino, Pijeira Díaz, Ruiz, & Kloos, 2017; Ruiz et al., 2014; Smith, 2015; Teusner et al., 2018; Yu, Wu, Liu, & Liu, 2021). 4 studies proposed different kinds of visualisations (Klusener & Fortenbacher, 2015; Sharma et al., 2016, 2020; Vinker & Rubinstein, 2022) for increasing awareness, motivating the learners and improving the learning experience. For example, Klusener & Fortenbacher (2015) reported the use of scatterplots and Sankey diagrams for instructors' awareness and stimulation of engagement.

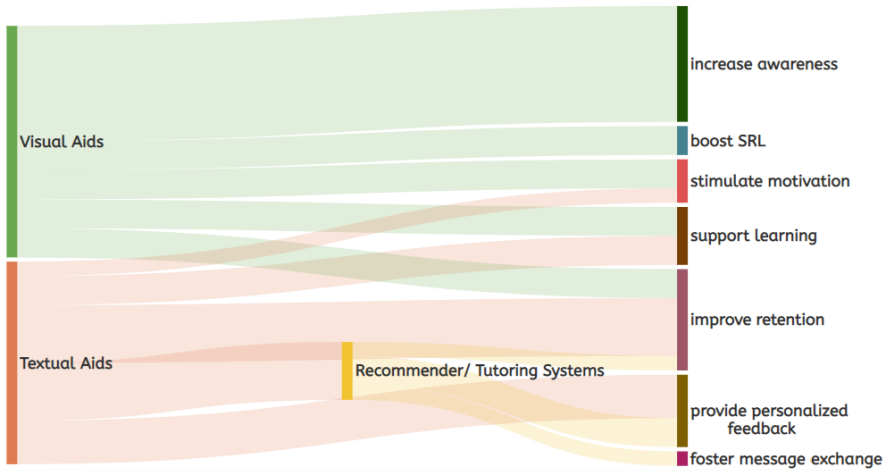


Figure 4.8. Relationship between the LA techniques applied and/or proposed and the feedback purposes.

The textual feedback regarded text messages, hints and prompts, tips and personalised links (Almeda et al., 2018; Caballe, Britch, Barolli, & Xhafa, 2014;

Ferschke et al., 2015; Frick et al., 2022; Lafifi, Boudria, Lafifi, & Cheratia, 2020; Lan, Vats, Waters, & Baraniuk, 2015; Meku-Fotso, Batchakui, Nkambou, & Okereke, 2020; Reza et al., 2021; Singelmann et al., 2019; Teusner et al., 2018; Wang, Lin, Rettig, Pardi, & Singh, 2017; Yılmaz et al., 2021; Yu et al., 2021). Almeda et al. (2018) proposed sending reminders with course-related material and praising the top-level discussion forum commenters. Wang et al. (2017), Lan et al. (2015) and Teusner et al. (2018) recommended the provision of specific suggestions to low-performing learners for correcting their assignments and exercises' errors and for practicing with additional material. Ferschke et al. (2015), Wang et al. (2017) and Singelmann et al. (2019) proposed the use of tools, such as peer recommender systems and data-driven automatic graders to facilitate the feedback provision, to promote message exchange among peers and to provide support tailored to learners' needs. Teusner et al. (2018) and Almeda et al. (2018) stressed the importance of self-communication and proposed messaging the non-active learners to encourage them to contribute to discussions and to motivate them to ask for help when struggling. Ferschke et al. (2015), Tomar et al. (2017) and Tegos et al. (2021) perceived as feedback the dialogue-based support given by peers or agents via conversational channels. Klusener & Fortenbacher (2015) and Xing et al. (2016) focused on designing effective interventions for dropout learners. They recommended informing instructors about potential dropouts and the reasons for which learners abandon the course, facilitating instructors to prioritise their interventions for such learners. Ferschke et al. (2015) presented the Quick Helper, a help-seeking tool that connects learners with peers to respond to unsolved questions. Lafifi et al. (2020) proposed a tool, TutMOOC, to empower instructors' role in tutoring. According to the learners' problem, the tool proposed different feedback agents, such as computer agents for simple automated solutions or instructors' mediation for pedagogical and learning problems. Tegos et al. (2021) proposed the use of conversational agents in dialogue-based MOOC activities, where the agent can trigger conversations among peers and scaffold participants' learning.

4.4.4. RQ4: Feedback Effects

The number of empirical studies (I.Q.4.3) was limited (n=4), thus not allowing conclusions about the impact of feedback supported by LA in MOOCs. Cobos and Ruiz-Garcia (2020) presented an LA dashboard, which informed instructors about learners' progress and helped them to deliver feedback to learners via personal messages. The intervention had positive effects on learners' motivation and course completion. Teusner et al. (2018) found that the learners who received recommended personalised material as automated feedback, performed better compared to those who did not receive material

tailored to their needs. Learners' self-reported satisfaction was positively affected as well. Ferschke et al. (2015) and Tomar et al. (2017) studied the feedback given via collaborative chat interventions. In Ferschke et al. (2015), the conversational support given on various channels helped the interactions and communication among peers. However, orchestrating learners' interactions over multiple communication media was demanding. Tomar et al. (2017) shed light on the number of peers participating in conversational interactions. The results suggested that small peer groups (i.e., dyads), formed by the automated computer assistance, were more effective than larger groups (e.g., more than two learners).

Some publications reported preliminary evaluations of the LA tools (I.Q.4.2) (n=17), or the delivered feedback interventions (I.Q.4.1) (n=3). The authors employed post-analysis of the participants' trace data testing for tool accuracy (n=17), surveys examining the aspects of usability and user experience (n=3) and lab experience (n=1). Out of the 20 proposals, 8 studies evaluated the technological tool presented. For instance, Rohloff et al. (2019) conducted user surveys with 217 MOOC learners regarding the benefits of the dashboard and the feedback given in the form of textual information. The findings showed positive results for learner satisfaction and tool usability. Likewise, Karaoglan-Yilmaz (2021) gathered students' perceptions about the use of a tool for providing scaffolding and tips when learners cannot overcome their problems. Authors conducted questionnaires to 53 undergraduate students exploring ease of use, disliked aspects, and features to improve the tool.

4.5. Discussion

Attending to RQ1: *What is the overall research state of the LA-informed feedback in MOOCs?*, the evidence gathered showed that the research interest on LA tools for feedback in MOOCs was varying withing the years, with higher peaks during the periods 2015-2018 and 2020-2021. Various reasons could have influenced such interest alternation. Lederman (2019) interpreted the decreasing interest in MOOCs after 2018 as an aftermath of the MOOCs' low completion rates. Reich & Ruipérez-Valiente (2019) discussed the change of MOOCs' purpose from open educational model into a degree-focused model (i.e., offering micro-credentials and Bachelor/Master-based degrees). This change could play a role on the waves of the general research interest, as well. Furthermore, during the last years, the COVID-19 pandemic shifted as well the educational landscape and led to an increased use of MOOCs at all educational levels, even in primary education (Chen et al., 2020; Impey & Formanek, 2021; Ma & Rindlisbacher, 2020). Thus, we hypothesize that the COVID-19 situation

boosted the research interest in the provision of feedback in massive contexts. Additionally, recent efforts from the LA community to provide actionable and human-centred LA interventions (Dimitriadis, Martínez-Maldonado, & Wiley, 2021; Shum et al., 2019) could be another reason for the rising interest in the topic of LA-informed interventions in MOOCs.

With respect to RQ2: *How is feedback designed in MOOCs in terms of the pedagogical theories followed?*, our findings suggest that many publications proposed tools and models aiming at increasing the awareness on learners' progress (n=17) or at providing personalised feedback through automated or semi-automated messages and recommendations to the learners (n=14). The most common pedagogical theory followed the principles of Self-Regulated Learning, according to which learners should be supported to become independent and self-regulated during their learning process (Zimmerman, 2000). Our results agree with the findings of Khalil et al. (2022) who found Self-Regulated Learning as the dominant theory informing LA proposals. Nevertheless, out of 38 publications analysed, only 8 publications reported using a particular feedback framework or learning theory to inform their LA tools. Such limitation indicates a lack of educational basis on the feedback systems and their foreseen interventions. Our results are compliant with Cavalcanti et al. (2021) and Jivet et al. (2017), who highlighted the general lack of a pedagogical underpinning on the LA tools encountered in online learning settings and in higher education. Ferguson & Sharples (2014) associated the absence of pedagogical frameworks in MOOCs with learners' disengagement and dropout. Previous works emphasized the need of contextualisation of the developed LA tools to provide meaningful interventions (Gašević et al., 2015; Knight & Buckingham Shum, 2017; Mangaroska & Giannakos, 2019; Ryan et al., 2019; Vieira, Parsons, & Byrd, 2018; Wise, 2018). Gašević, Kovanović, & Joksimović (2017) emphasised the importance of the learning theory in LA innovation and proposed a LA model that suggests the inclusion of the learning theory into LA research and practices.

Regarding RQ3: *How is LA applied in MOOCs to result in relevant information for feedback?*, the evidence gathered showed a variety of LA tools supporting feedback, having learners' log data as a primary source to inform the interventions. The technological tools developed for informing feedback interventions were mainly dashboards, recommender systems or other types of tools to provide feedback in the form of reminders, recommendations to low-achievers, motivational messages for encouraging learners to self-report their challenges, etc. Nonetheless, the reviewed manuscripts did not consider the provision of guidelines nor further input to facilitate users' understanding and application of the LA information. It is worth mentioning that users often

face difficulties to interpret and make use of the LA information (Fernández-Nieto et al., 2022; Matcha et al., 2020; Rienties et al., 2018). Indeed, Mangaroska & Giannakos (2019) reported that although there are plenty of LA tools, instructors still need guidance to comprehend and fruitfully use LA in their learning practices. According to Ryan et al. (2019), to result in effective interventions, LA tools should facilitate the users' understanding without focusing simply on the transmission of the information.

In regards to RQ4: *What are the reported effects of the instructor-led LA-informed feedback interventions in MOOCs?*, we intended to explore the impact of the examined contributions in authentic settings. However, the findings indicate a lack of empirical applications and evaluations in authentic MOOC settings. Concretely, only 4 studies reported an empirical assessment of their technological and conceptual proposals. This fact hinders a deeper understanding of the efforts on LA-based feedback and suggests that the field is still at an early stage. Future work is needed on more solid and elaborated proposals to become mature. Our findings agree with the current state of LA interventions in Higher Education (Tsai, 2017; Viberg, Hatakka, Bälter, & Mavroudi, 2018) and in MOOCs (Zhu, Sari, & Lee, 2022). Conclusively, there is a general discrepancy between the research attention and the contributions delivered in the educational landscape (i.e., evidence-based evaluations).

In summary, this systematic literature review helped to dive into the current state of instructor-led LA-informed feedback interventions in MOOCs. The results suggest that this concrete research area inside LA is still evolving, given the increasing interest in the topic, the variety of proposed solutions and the growing number of journal papers. Nevertheless, the review showed a lack of empirical studies exploring the use of LA to inform feedback in MOOCs and to measure the effects of this feedback on learning. Hence, there is need for rigorous empirical evaluation of the overall impact of LA-based feedback in massive learning contexts.

Furthermore, the systematic literature review suggested that the reviewed proposals: a) do not take into account pedagogical theories, and b) do not frame the feedback design in an a priori reflection on learning goals, feedback aims, learning topic, and context. The above limitations, if overlooked, may affect the success of the feedback interventions. Concretely, the lack of a pedagogical underpinning of the LA tools to shape feedback can lead in less instructive interventions, neglecting important feedback aspects, such as the different levels on which the feedback can impact the learners (e.g., in a cognitive, motivational or performance level) or the appropriate timing of delivering feedback. Additionally, the lack of contextualisation in the course particularities (e.g., course context, learning topic) may result in less

meaningful LA data. Therefore, the LA-informed feedback decisions might not satisfy the learners' needs and the course learning goals. A way to tackle these issues could be through a participatory approach by actively involving the course instructors, not simply as end-users of the LA information but as co-designers when reflecting on the LA requirements (e.g., to co-select or finetune which metrics should be used to monitor learners' progress). Finally, the systematic literature review indicated that the LA tools do not provide guidance to the course instructors during such a process of how to design feedback strategies beforehand.

This work presents certain limitations that can serve for future research. This systematic literature review followed the guidelines proposed by Kitchenham & Charters (2007). However, we acknowledge that specific decisions we took while conducting the review, may have discarded some studies related to the topic under study. For example, the search string applied was very specific and it might not have captured all potential publications. Another important limitation is the scarcity of the literature on the topic. Despite the rich research on LA-informed feedback in other contexts, such as in higher education or online education, the lack of prior work on instructor-led LA-informed feedback in MOOCs challenged the researchers and did not permit the generalisation of the results.

4.6. Conclusions

The current chapter presented a systematic literature review that aims to contribute to the comprehension of the existing efforts for instructor-led LA-informed feedback in MOOCs. This systematic literature review is the first contribution of the dissertation and aimed at attaining the first thesis objective #OBJ_1.

The evidence gathered shows an interest over time on using LA for generating feedback information and shaping interventions. At the same time, the systematic literature review revealed a scarcity of empirical studies, a lack of pedagogical and contextual grounding of the presented LA and a lack of guidance provided to course instructors on how to understand and use the LA data to create suitable interventions. All these identified limitations related to the design of personalised feedback interventions, together with the limitations identified in the exploratory studies led us to propose FeeD4Mi. FeeD4Mi is a conceptual framework to guide MOOC instructors in the design and provision of LA-informed feedback in massive contexts (second thesis contribution #CON_2). The synthesis of the findings illuminates aspects of the proposed framework, presented in detail in the next chapter. In particular, the findings also motivated some components of the framework, such as the

consideration of the course LD before designing feedback interventions (see Section 5.3.2). Additionally, the indicators reported in the reviewed papers enriched the FeeD4Mi catalogues. As presented in the next chapter, these catalogues will also help instructors in the design of feedback strategies by suggesting potential problems, behaviours and reactions that might happen in their MOOCs (see Section 5.3.3).

Chapter five

FeeD4Mi: The 'Feedback Design for MOOC Instructors' Framework

Summary: The lessons learnt from the exploratory studies (Chapter 3) and the conducted systematic literature review (Chapter 4) indicated the need of conceptual and technological tools to guide MOOC instructors in the design and delivery of personalised feedback. Previous works proposed LA models and frameworks to **automate the provision of instructor-led personalised feedback**. However, these proposals do not guide instructors in the process of reflecting on feedback-related aspects (e.g., feedback type). Additionally, they do not support MOOC instructors in the interpretation and selection of the LA indicators associated with the LD. To address the aforementioned needed, this chapter proposes the second contribution of the current dissertation: **the conceptual framework FeeD4Mi**. The framework consists of four components aimed to guide MOOC instructors in the design and provision of LA-based feedback interventions, and to enable the digital representation of the feedback designs, thus saving time and effort to MOOC instructors. This chapter presents each one of the above FeeD4Mi components.

This Chapter is based on the following publications:

Topali, P., Ortega-Arranz, A., Martínez-Monés, A., Villagra-Sobrino, S., Asensio-Pérez, J. I., & Dimitriadis, Y. (2021). Identifying Learner Problems Framed within MOOC Learning Designs. In: *Proceedings of 29th International Conference on Computers in Education Conference,* ICCE 2021. pp. 297–302.

Topali, P., Ortega-Arranz, A., Chounta, I. A., Asensio-Pérez, J. I., Martínez-Monés, A., & Villagrá-Sobrino, S. l. (2022). Supporting instructors in the design of actionable feedback for MOOCs. In: *Proceedings of IEEE Global Engineering Education Conference*, EDUCON2022. pp. 1881-1888.

Topali, P., Cobos, R., Agirre-Uribarren, U., Martínez-Monés, A., & Villagrá-Sobrino, S. l. (2022).

Co-Design and Evaluation of Instructor-led LA-informed Feedback in MOOCs. *Under Review.*

Ortega-Arranz, A., **Topali, P.**, Asensio-Pérez, J.I., Villagrá-Sobrino, S.L., Martínez-Monés, A., Dimitriadis, Y. (2022). e-FeeD4Mi: Automating Tailored LA-Informed Feedback in Virtual Learning Environments. In: *Proceedings of the 18th Conference on Technology-Enhanced Learning.* Springer, Cham. pp. 477-484

5.1. Introduction

The current chapter delves into the second and third objectives of this thesis, respectively: i.e., *to help instructors to shape personalised and contextualised feedback interventions in MOOCs* (OBJ_2) and *to make manageable the design (and provision) of feedback for MOOC instructors* (OBJ_3). Figure 5.1 depicts the connections between the research question, the objectives, and the contributions formulated in this chapter.

To address the limitations identified previously in the systematic literature review and in the three exploratory studies, we propose the FeeD4Mi framework. FeeD4Mi aims at helping instructors to reflect on their feedback practices and then to design their interventions in authentic MOOC settings. The methodological approach followed during this dissertation. i.e., Design-Based Research (see Section 1.3) guided the design and the development process of the proposed framework. The design and development process spanned the four iterative cycles mentioned in Chapter 1. The current chapter introduces the final version of the framework.

FeeD4Mi encompasses the following components: a) five dimensions that indicate the aspects that should be considered for the design of personalised LA-feedback interventions (see Section 5.3.1), b) a process to guide MOOC instructors in the design of the feedback interventions (see Section 5.3.2), c) a set of catalogues with recurrent problems, indicators, and reactions in MOOCs to foster reflection on personalised feedback (see Section 5.3.3), and d) a set of recommendations connecting potential learners' problems with LA-based indicators and feedback reactions (see Section 5.3.4). Additionally, to address the need of manageability of the feedback designs, FeeD4Mi provided a set of design guidelines to incorporate FeeD4Mi into technological tools. The design guidelines aim to enable the creation of computer-interpretable feedback designs (see Section 5.5).

The current chapter is structured as follows: Section 5.2 discusses previous solutions similar to FeeD4Mi, i.e., LA proposals that actively involve instructors in the design and selection of metrics to deliver personalised feedback. Section 5.3 presents the FeeD4Mi framework, and Section 5.4 illustrates a scenario of use of the framework. Section 5.5 introduces the design guidelines. Finally, the chapter concludes with several remarks about the relevance of this contribution (see Section 5.6).

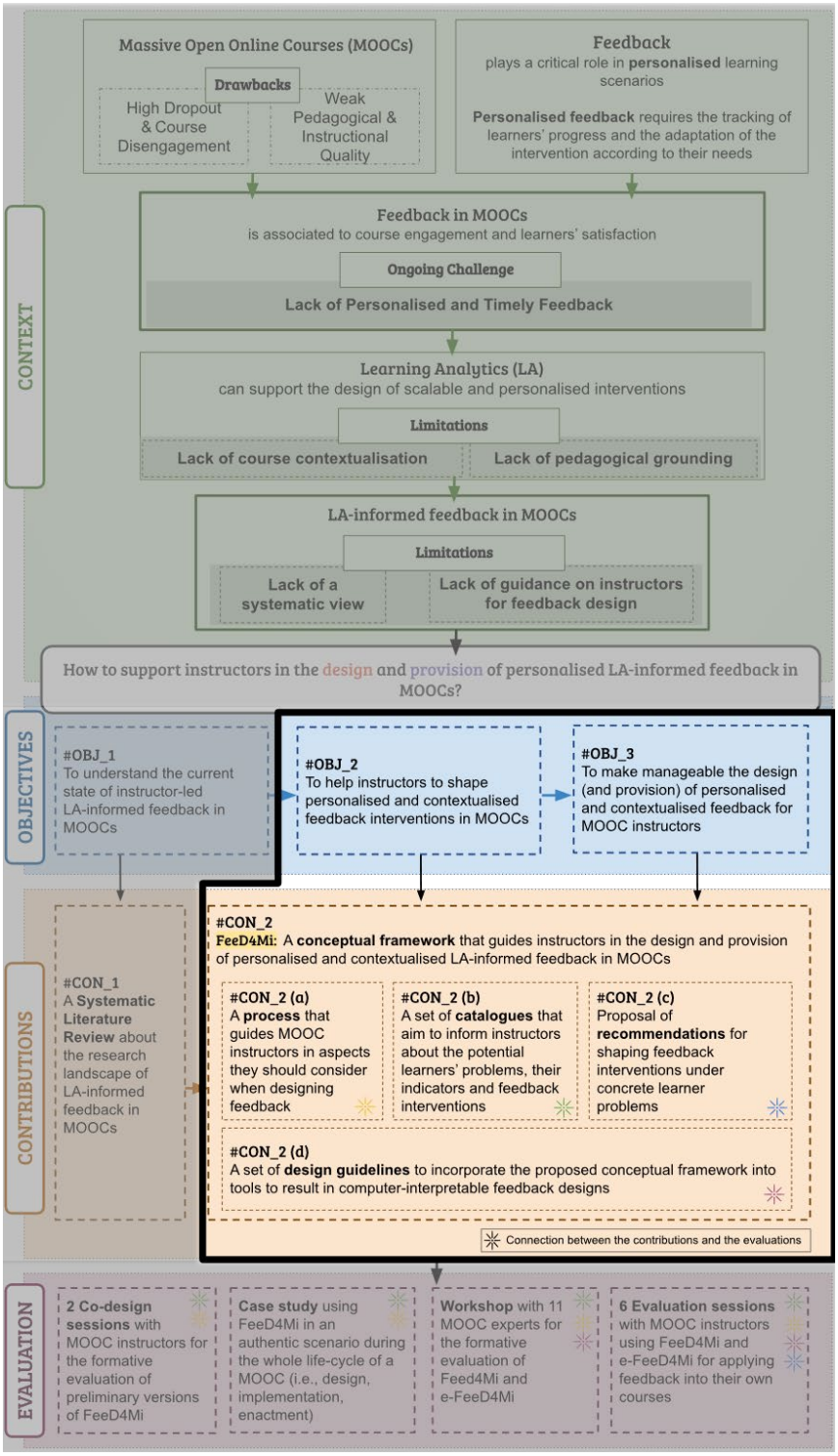


Figure 5.1. Overview of the research objectives and contributions addressed in Chapter 5.

5.2. Related Work

In massive contexts as MOOCs, monitoring learners' progress manually to provide targeted support is not trivial. As a result, there are several data-driven tools, as uncovered by our systematic literature review (see Chapter 4) that automate both the detection of struggling learners and the provision of feedback interventions. For example, Kochmar et al. (2020) and Lafifi et al. (2020) proposed the use of intelligent tutoring systems to timely track learners' behaviours and deliver personalised LA-informed interventions in MOOCs. The LA tools use large learner datasets to develop predictive models and detect learner cohorts, neglecting the nature of the different courses and their associated specific contextual information (Avella et al., 2016). Building on the need of achieving context awareness together with the LA information to provide more informed interventions, several tools, models, and frameworks attempt to position actively the human agents in the process of designing, selecting, and/or fine-tuning LA indicators to provide personalised feedback to their learners. These tools provide a high-level autonomy to instructors to adapt the LA tools according to their pedagogical needs. In this section we discuss related works, and we address the similarities and differences with FeeD4Mi.

Burgos & Corbí (2013; 2014) proposed a recommendation model, that supports personalisation in informal and formal online learning scenarios, named L.I.M.E (i.e., Learning, Interaction, Mentoring and Evaluation). Using LIME instructors consider aspects of course design and learners' behaviour and pass from four dimensions to create rule-base feedback strategies. The instructors decide in advance recommendations that are delivered automatically when the learners satisfy the rule-based conditions. The authors implemented LIME into a software application named iLIME to be able to apply the model in various learning management systems. Similarly, Liu et al. (2017) proposed Student Relationship Engagement System (SRES), a LA tool that aims to help higher education teachers to provide personalised feedback through of the use of email messages. SRES supports a high-level human agency, by permitting teachers to set pre-fixed conditions based on students' course behaviours (e.g., "*if the Moodle platform visits are less than 4 times, then send an email message reminder*", "*if mid-semester test is empty, then send an automated email message*") and to customize feedback messages with concrete recommendations. Likewise, Pardo (2018) developed a data-driven feedback model though which the actors of the learning process (i.e., instructor, expert, peer or a computing agent) are able to give personalised comments to different cohorts of students at critical course moments based on students' engagement with their tasks. Specifically, the feedback providers review and evaluate the

students' course activity against pre-defined conditions and intervene with targeted messages. Additionally, such model has been implemented into a web-based LA tool, named OnTask, that enables higher education instructors to choose data-driven indicators, set if-then conditions and provide personalised feedback through email messages to specific student cohorts (Pardo et al., 2018). Recently, Reza et al. (2021) created the MOOClet framework, that among other options, enables the course instructors to define if-then rules and, thus to deliver feedback in form of concrete explanations and recommendations based on learners' engagement. Yet, the application of the rules requires the researcher's intervention, a fact that may restrict instructors' independence and flexibility.

In summary, the abovementioned proposals build rule-based feedback according to the learners' behaviours during the course enactment. All the above research works support the active involvement of the human factors, i.e., instructors, in choosing or parametrising the LA-based conditions for providing personalised feedback. Nevertheless, none of the previous proposals support a definition of the ruled-based conditions according to the course LD elements (e.g., to specify the assignment difficulty, the compulsory/optional tasks). Bakharia et al., (2016) remarked the explicit consideration of LD aspects for successful LA-informed decisions. Additionally, from the suggested models, only the proposal from Reza et al. (2021) was designed taking into account the specific characteristics of MOOCs. The remaining works discuss interventions in higher education or online learning different than MOOCs. In the process of designing feedback in MOOCs, we should consider their massive context that invites learners of diverse background and needs, because different types of learners' problems might occur given this context (Conole, 2016).

Finally, to the best of our knowledge, none of the aforementioned models provide guidance to the involved stakeholders both in reflecting, using, and applying LA information and in selecting particular feedback aspects. As stated previously, instructors (especially novice ones) may need guidance to make the connections among LA and LD (Mangaroska & Giannakos, 2019) and to successfully connect such indicators with the feedback interventions. Feedback is influenced with decisions related to the timing, the content, and the type of support (Hattie & Timperley, 2007; Molloy & Boud, 2014). Instructors may ignore such aspects, especially if they do not have previous experience in MOOC settings. Thus, the provision of guidance on how to design feedback for large scale may require a more supportive approach. We deem that one way to achieve this guidance could be through a process that directs the user about the aspects to reflect on related to personalised feedback. Additionally, the

provision of catalogues and recommendations could facilitate even more the decision-making through concrete ideas and suggestions already applied in MOOCs.

5.3. FeeD4Mi: The 'Feedback Design for MOOC Instructors' Framework

The previous section discussed several LA framework and models for supporting instructor-led feedback interventions and highlighted their limitations regarding the lack of guidance in the design of personalised feedback strategies (e.g., comprehension of the LA indicators). To overcome such limitations, in this section we introduce the 'Feedback Design for MOOC Instructors' Framework, FeeD4Mi. FeeD4Mi is a conceptual framework aiming to support instructors in the reflection and design of personalised feedback in MOOC environments. The following subsections present the four fundamental components of FeeD4Mi, i.e., the FeeD4Mi dimensions, the process, the set of catalogues and the set of recommendations.

5.3.1. FeeD4Mi Dimensions

FeeD4Mi is organised around five dimensions (see Figure 5.2):

- *Learning Design*: The first FeeD4Mi dimension describes the course particularities (e.g., course structure, resources, the association among the resources) that instructors should outline. The 'Learning Design' dimension emerged given the importance stressed to LD to be considered explicitly when designing LA interventions (Bakharia et al., 2016; Gašević, Dawson, Rogers, & Gasevic, 2016; Lockyer et al., 2013) and even more when positioning the human actors at the centre of such processes (Dimitriadis et al., 2021).

- *Learner Problems*: The second FeeD4Mi dimension describes the potential problems that MOOC learners can face during the course enactment. The exploratory work conducted (see Chapter 3) and the literature review revealed a set of learners' problems that are common across MOOCs of different disciplines. We deem that providing a list of such problems to instructors can facilitate them in the design of feedback interventions. As seen previously, instructors may face difficulties in reflecting directly on which indicators to apply to identify learners that potentially face a problem. Thus, this dimension aims to help MOOC instructors during the reflection and identification of behaviours of struggling learners. Additionally, it sets the basis for the

recommendations provided to instructors about defining the indicators and feedback reactions that are suitable for each problem.

- *Problem Indicators:* The third FeeD4Mi dimension concerns the selection of indicators for the detection of behaviours of potential struggling learners. These indicators are based on the learners' trace data generated during the course. The inclusion of this dimension is related to the aim of the current dissertation (i.e., to support MOOC instructors in providing personalised LA-feedback) and of the human-centred approach adopted. As a result, we involve instructors in the process of reflecting and selecting the LA indicators based on learners' trace data.

- *Feedback Rules*: The fourth FeeD4Mi dimension involves the instructors' possibility to adapt the indicators of the previous dimension by fine-tuning their thresholds to create if-then rules and conditions. The third and fourth FeeD4Mi dimensions are in compliance with the processes regularly followed by several instructor-led LA tools, such as the ones presented in Section 5.2, regarding the creation of rule-based decisions.

- *Feedback Reactions*: The last FeeD4Mi dimension is related to the different feedback aspects that MOOC instructors needs to consider in order to shape successful feedback interventions. These aspects were presented in Section 2.4.2 and are related with the timing of feedback, the feedback provider (e.g., instructor, context, peers) and the type of feedback intervention.

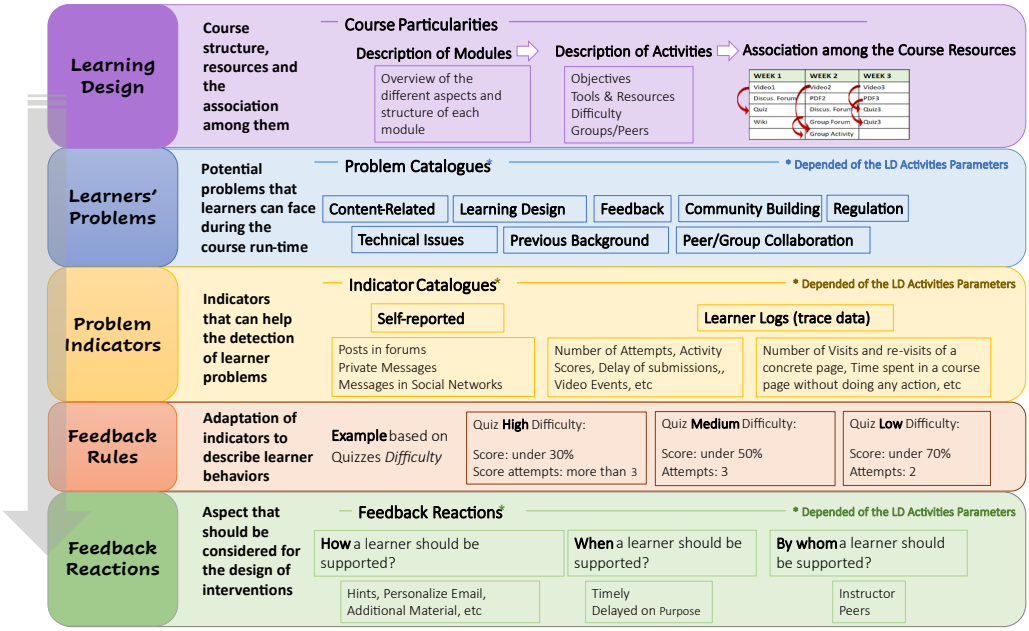


Figure 5.2. Graphical representation of the FeeD4Mi conceptual framework, that briefly depicts the process and the examples of the catalogue suggestions.

FeeD4Mi is foreseen to be used at the design phase of a MOOC and is expected to assist MOOC instructors to: a) reflect and detect potential learner problems related to the course LD, that can be challenging during the learning process in MOOCs, b) define behaviours of potentially struggling learners and c) decide the adequate feedback intervention tailored to the learners' behaviours.

5.3.2. FeeD4Mi Process

The FeeD4Mi dimensions are organised under a concrete process through which, instructors are expected to start from a reflection on the pedagogical aspects of their course (Learning Design dimension), and on possible struggling behaviours of learners (Learner Problem and Problem Indicators dimensions) to come up with feedback interventions adapted to the different behaviours identified (Feedback Rules and Feedback Reactions). Concretely:

- **Outline the course Learning Design:** At the first phase of the FeeD4Mi process, instructors should describe their course, specifying its module structure, the associated activities, and the association among the course aspects (i.e., the learning sequence/path that should be followed (e.g., which video or pdf is related with which activities). Concretely, instructors should specify:

- *the difficulty of the activities.* Mason & Bruning (2001) at their feedback framework highlighted that feedback should vary depending the difficulty of the course activities (e.g., quiz, assignments).
- *the type of the activities.* Previous research pointed out different engagement of learners depending on their modality: optional or compulsory (Winstone, Mathlin, & Nash, 2019) and individual or collaborative (Nawrot & Doucet, 2014). This fact was also observed in our first exploratory study [Exp_1], indicating different types of problems in individual and collaborative activities.
- *the consideration of certain milestones.* Milestones refer to critical course activities set by instructors (e.g., a checkpoint or an important assignment). By reaching these milestones (or not), learners' path might be affected positively or negatively. Reflecting on milestones emerged relevant during our first evaluative study (see Section 6.2.1). Actually, Lockyer et al. (2013) also supported the use of checkpoints as a useful practice for instructors to better monitor the progress of their learners.
- *the sequence of the learning tasks and the connection among the course resources*. Lockyer et al. (2013) highlighted the sequence among the course resources as a key element in the reflection of the LD. For example, learners might struggle with course quizzes because they did not understand or even watch the video where the answers to the quiz are.

We place this dimension at the beginning of the FeeD4Mi process, due to the necessity of contextualising the feedback strategies with the course LD (Bakharia et al., 2016; Gašević et al., 2016).

— **Reflection on potential Learners' Problems**: This FeeD4Mi phase concerns instructors' reflection on potential learners' problems that might occur during the course enactment. Thus, instructors can be prepared a priori to address such problems. Passing from the previous step is expected to help instructors to connect the potential learners' problems with their own course LD. Learners' problems can be related with understanding issues, lack of previous background, peer collaboration or with the course design itself. FeeD4Mi catalogues (see Section 5.3.3) can serve as suggestions for further problem ideas. Moreover, the process recommends instructors to prioritise the envisioned problems in this phase and select the ones they would like to

intervene. For example, as seen in [Exp_3], while an instructor may think that learners can face community building problems as well, they might not be interested in intervening these kinds of issues.

- **Reflection on Problem Indicators**: The next step regards the reflection and selection on behalf of the instructor of the indicators that could help in the detection of behaviours of struggling learners, according to the potential problems identified in the previous phase. For example, a content understanding issue could be identified by observing low scores in quizzes or learners' several views of the same content video. In this regard, FeeD4Mi also propose a set of catalogues and recommendations (see Sections 5.3.3 and 5.3.4, respectively) that serve as suggestions for the selection of indicators.

- **Creation of Feedback Rules**: During such phase, instructors finetune the indicators chosen before that will trigger the feedback reactions by setting critical thresholds according to the course LD. For instance, rewatching the main video of the module several times in a row might be considered acceptable if the module difficulty is high, and it might be warning if the module difficulty is low. Additionally, in that step instructors can determine which set of problems and indicators can be applicable based on the available course tools. That is, while the number of pauses in a video may be considered relevant for detecting content understanding problems, the platform might not capture such video events. While reflecting on problems and indicators that can be interesting to be addressed, but are not applicable within the MOOC platform used, instructors can realise the limitations of the used tools and find alternative solutions.

  We deem this step essential, since apart from selecting relevant indicators, setting the indicator thresholds considering the course LD is the step that will enable more informative interventions. This phase is common with other human-centred approaches. For instance, Chatti et al. (2020) proposed a framework for the design of LA indicators. While the focus of their framework is different, in the process proposed by Chatti et al. (2020) the instructors are involved actively in the detection and finetuning of the indicators useful for them with the final aim the most appropriate visualisation of such indicators according to instructors' needs.

- **Reflection on Feedback Reactions**: The FeeD4Mi process ends with the design of the feedback interventions according to the identified potential

learners' problems. Specifically, FeeD4Mi let instructors to decide several feedback related aspects to complete their interventions. These aspects are retrieved from the recommendations of Mason & Bruning (2001), Molloy & Boud (2014) and Shute (2008):

- the type of intervention (e.g., hint, informal tutoring),
- the intervention timing (i.e., instant, or delayed)
- the means via which the intervention will be delivered (i.e., via email, platform notification, course enhancements or visualisations).

For instance, an instructor may choose to provide instant hints through platform notification when a concrete learner behaviour is detected. As it happened with the phase of 'Problem Indicators', during this phase as well FeeD4Mi provides catalogues and recommendations (see Sections 5.3.3 and 5.3.4, respectively) to suggest ideas related to the feedback reactions.

Figure 5.3 depicts the FeeD4Mi process step-by-step. The user should move forward from the first FeeD4Mi dimension to the next one. However, the FeeD4Mi process foresees the possibility of returning backward among the phases to edit or add aspects to the feedback strategies. For instance, if the instructors detect limitations of the platform to support a chosen indicator, then they can re-configure the chosen indicators and select new ones. Additionally, in case the users realise further potential problems at the last steps given the FeeD4Mi catalogues or the recommendations, then they can return to the previous phase of R*eflection of potential Learners' Problems* and add further problems.

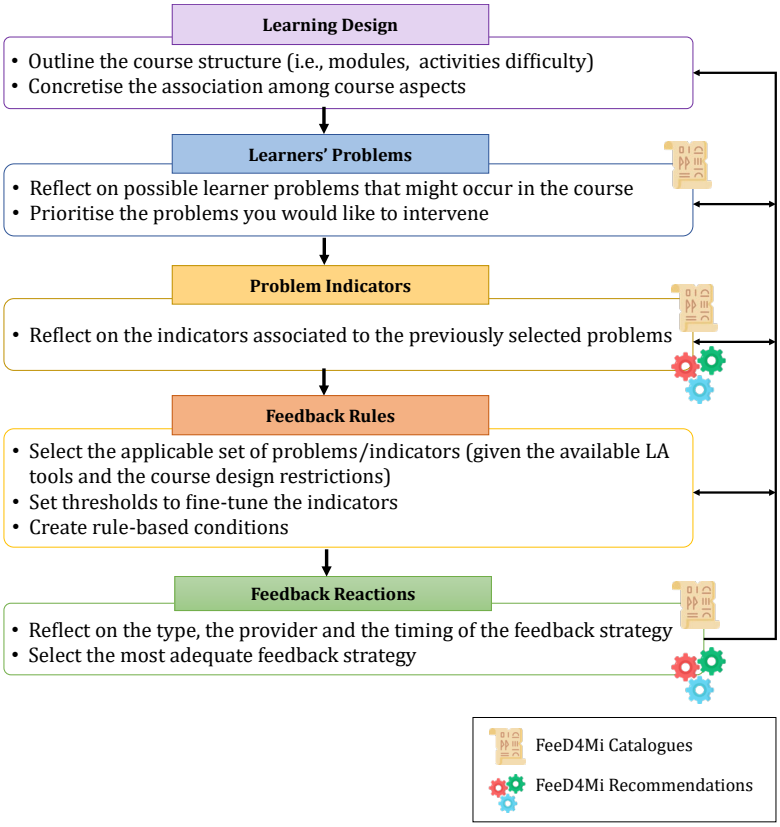


Figure 5.3. Illustration of the FeeD4Mi process.

5.3.3. FeeD4Mi Catalogues

As described in the aforementioned process, FeeD4Mi also includes a set of catalogues regarding:

- potential learners' problems that might happen in MOOCs,
- indicators describing learners' behaviours within the platform and course activities, and which can be used to identify potential problems,
- recurrent feedback interventions that can help address the identified problems.

These catalogues aim to help MOOC instructors, especially the non-experienced ones, to consider as many aspects as possible related to the design of feedback strategies. The three catalogues were informed by the literature (see Chapter 2) and our exploratory work (see Chapter 3) and they were further enhanced during our evaluation experiences (see Chapter 6), following a DBR methodological approach. The tables below present the catalogues of: learners' problems (see Table 5.1), indicators (see Table 5.2) and feedback

reactions (see Table 5.3). Appendix C offers detailed information about the research works that informed each catalogue.

Catalogue of Potential Learners' Problems

The first catalogue, the catalogue of potential learners' problems, includes 8 problem categories (e.g., problem related to previous background knowledge) with some of them to be further divided into more concrete issues (e.g., activities perceived as too difficult or too easy). To define such problems, we reviewed the literature and conducted the exploratory studies present in Chapter 3. Given the iterative nature of our methodological approach, specific subcategories emerged during our evaluation studies. For instance, the research from Nawrot & Doucet (2014) and two of our exploratory studies ([Exp_1] and [Exp_3]) informed FeeD4Mi about potential learners' problem of collaboration, either with their peers or a larger groups of learners. However, during our evaluative studies, the participants proposed more specific issues to be included in FeeD4Mi, i.e., absent-non active group members, unequal peer contributions to collaborative activities or unfair grading received by peers (too easy or to tough graders). Table 5.1 presents the catalogue of learners' problems, depicting all the categories and subcategories and their descriptions. A more complete account of these categories, including the research works that informed each problem is presented in Table C.1, see Appendix C.

Table 5.1. Catalogue of Learners' Problems

Problems Categories	Problems	Description
Content Understanding	Content Understanding	A learner finds it challenging to understand the provided content material.
Previous Background *Issues related with the previous level of knowledge of the learners*	Activities too difficult	A learner finds the level of the activities difficult to proceed (content)
	Activities too easy	A learner finds the level of the activities easy to proceed (content)
Regulation *A learner has problems affecting their regulation in their learning*	Deadline Issues	A learner faces problem to meet course deadlines
	Self-regulation Issues	A learner lacks self-regulation skills (e.g., planning the learning process, sustain throughout the learning process
Peer/Group Collaboration *Issues related with the peer/group collaboration*	"Ghost" members (i.e., absent- non active members)	The group/ peer members are not present to do the activity
	Unequal contributions to activities	The group members do not participate equally within the group/peer activity
	Easy/ Tough graders	The group/peer members do not grade objectively
Feedback	Lack of instant feedback	Instructor, TAs or peers do not provide timely feedback (absent members)

Issues related to the provision of feedback	Lack of useful feedback (e.g., in peer reviews)	Peers do not provide useful feedback (easy graders)
Community Building *Issues regarding the feeling of community-belonging*	Lack of social interaction/Feeling of Isolation	A learner feels isolated due to the lack of interaction within the discussion forums or other communication threads
Technical Problems *Issues related with technical aspects of the course*	External links that do not work	A learner faces problems with inactive course links
	Platform Problems	A learner faces various platform problems, such as difficulty in navigation
Learning Design (LD) *Issues related with the LD of the course*	Learning Path	A learner finds it difficult to navigate through the course modules
	Critical Points/Milestones	A learner misses or passes milestones set by the course instructor as critical course components (i.e., course videos/readings)

Catalogue of Problem Indicators

Attending to the catalogue of problem indicators, the indicators were retrieved from the systematic literature review presented in Chapter 4. We gathered additional information from our second exploratory work [Exp_2], as studied within an authentic MOOC context. Briefly, we grouped the encountered indicators into 5 categories, given the different course resources they are associated with. Table 5.2 shows the FeeD4Mi indicators.

Table 5.2. Catalogue of Problem Indicators

Type of Resources	**Type of Actions**
Content Page (Videos/PDF Readings)	Visit Download Watch (the videos) No visits No downloads No watches
Assignment/Quiz	Visit Submit Passed-Failed Submissions Passed with 'Honor' Score Number of Attempts Hints used Submission Length *(maximum and minimum characters)* Submission Content *(use of predefined terms)* Repetition of failed answers No visits No submissions Time spent
Peer Assignments	Visit Submit Receive comments Number of comments No Visits

	No submissions Not received comments Time spent
Discussion Forums	Basic forum activity *(i.e., posts entries, post replies)* Up-votes/ down-votes given or received per post Likes given or received per post Post length *(maximum and minimum characters)* Post Content *(use of predefined terms)* Forums visits without further action *(i.e., posts entries, post replies)*
Platform	Log in Log out Send a message to instructor Time spent Sequence of failed-passed submissions within the course modules Low over scores within the course modules Number of uncompleted of previous compulsory assignments/quizzes Entries in different discussion forums (e.g., group & general discussion forums) Visits in different discussion forums (e.g., group & general discussion forums)

Catalogue of Feedback Reactions

In regard to the catalogue of feedback reactions, its synthesis followed the feedback taxonomy of Hattie & Timperley (2007), considering that their taxonomy is the most applied one in feedback literacy and it provides a typology about the feedback reactions within each of the focus areas of feedback (Lipnevich & Panadero, 2021). Accordingly, we formed the catalogue into the four suggested categories and later associated ideas of interventions based on the taxonomy, further proposals of the literature and our evaluative studies. Table 5.3 presents the catalogue of feedback reactions. The taxonomy of Hattie & Timperley (2007) classified the feedback focus into 4 levels:

- Task level: the correctness of a task or an artefact to be delivered.
- Process level: the process applied to deliver and complete a task.
- Regulation level: the learners' self-regulation involving the skills to acquire self-confidence and self-efficacy.
- Self level: feedback about oneself as a person without any (or little) connection with the task. The self-level is the least applied in the learning process, due to such lack of connection with the learning itself (Hattie & Timperley, 2007). For example, feedback on self-level concerns messages such as 'good boy'.

Apart from the ideas of feedback interventions, the process asks instructors to consider the means of delivering such interventions (e.g., via email, platform notifications) and the timing for delivering them (i.e., delayed, or instant support). Building on the findings of [Exp_3], the type of learner problem often determines the intervention timing. Concretely, we found that

when a learner's problem regards technical issues, instructors tend to act immediately. However, if the nature of a problem is content-related then instructors respond belatedly in order to let the learner either to communicate with their peers or to try harder to overcome the problem. Mason & Bruning (2001) considered in their feedback model that the feedback timing depends on the learner achievement and the task level. That is, when a learner performs low, then the feedback intervention should immediate regardless the level of the task. Yet, when a learner is high performing, then immediate feedback should be delivered to lower-level tasks and delayed to tasks that require higher cognitive elaboration. Considering the aforementioned ideas, FeeD4Mi offers the possibility to MOOC instructors to reflect upon such issue and define the timing of delivering the feedback intervention, according to their criteria. Further details about the research works that informed each indicator is presented in Appendix C, Table C.2.

Table 5.3. Catalogue of Feedback Reactions.

Feedback Focus	**Description of Feedback Aim**	**Feedback Intervention**
Self	Reactions related to praising the learner	Praising/motivational messages
Task	Reactions relating to how well a task has been accomplished	Messages about correct/wrong answers
		Gamification (i.e., Badges, Leaderboards)
Process	Reactions related to the processes needed to perform a task	LD adjustments *(i.e., extend deadline, extra attempts, allow to skip, re-open activity, pass with lower score)*
		Hints/Cues
		Online informative tutoring/ Guest Speakers
		Positive/Negative Exemplars
		Commonly asked questions/ Rubrics/Guides
		Provision of additional material
		Re-assign peer/group member
		Mentoring/Connect with other learners
		Discussion prompts, Targeted forums
Self-Regulation	Reactions related to self-monitoring and self-direction	Gamification (i.e., Badges, Leaderboards)
		Provision of performance statistics *(compared with other learners)*
		Provision of performance statistics *(compared with instructor expectations)*
		Predefined message to (re)visit content material
		Motivational messages
		Reminders

5.3.4. FeeD4Mi Recommendations

The last FeeD4Mi component is a set of recommendations that link each learners' problem with indicators and feedback reactions. The idea of providing recommendations emerged during the third evaluative study [EV_3] (see Section 6.2.3). Specifically, in the [EV_3] the participants proposed the additional provision of good practices or ready-made examples. They deemed that these good practices could facilitate them in making connections among learners' problems, indicators and feedback reactions and in reducing the time-consuming process of deciding all the feedback aspects from scratch.

Table 5.4 describes the FeeD4Mi recommendations under each learners' problem. The evidence gathered from the systematic literature review (see Chapter 4) and the first three evaluative studies (see Sections 6.2.1, 6.2.2 and 6.2.3) informed these recommendations. For example, regarding the problem of previous background, we checked the indicators that the previous LA tools in MOOCs used for that concrete problem. Additionally, we added more proposals from the participants' suggestions during [EV_1] and [EV_3].

Table 5.4. Recommendation of feedback strategies under concrete learner problems.

Problems	Associated Indicators	Associated Feedback Reactions
Content Understanding	Self-Reported: *emails, forums post* Platform: *Low overall scores / Many failed submissions* Assignments/Quizzes: *Low scores / Much time spent / Several failed submissions / Several attempts used / Repetition of wrong answers / Many hints used / Many students failing* Content Pages: *Much time spent / Many visits / many video replays* Discussion Forums: *many entries*	Self-related Feedback: *praising messages* Process-related Feedback: *Restart activities (LD changes) / deadlines extension (LD changes) / provision of additional material /Mentoring/Connect with other learners* Self-regulation Feedback: *Motivational emails/notifications / reminders /Badges*
Previous Background	Self-Reported: *emails, forums post* Platform: *Low overall scores / Many failed submissions* Assignments/Quizzes: *Low scores / Much time spent / Several failed submissions / Several attempts used / Repetition of wrong answers / Many hints used / Many students failing* Content Pages: *Much time spent / Many visits / many video replays* Discussion Forums: *many entries*	Self-related Feedback: *praising messages* Process-related Feedback: *Restart activities (LD changes) / provision of additional material /Mentoring/Connect with other learners* Self-regulation Feedback: *Motivational emails/notifications / reminders /Badges*
Regulation	Self-Reported: *emails, forums post* Assignments/Quizzes: *delays on submissions* Discussion Forums: *many entries*	Self-related Feedback: *praising messages* Process-related Feedback: *deadline extensions (LD changes) / provision of additional material*

	Platform: *high number delayed previous assignments* Platform: no visits on critical milestones /low overall scores / high-little time spent in course pages	*/Mentoring/Connect with other learners* Self-regulation Feedback: *Motivational emails/notifications / reminders /statistics about the learner's performance in association to others / statistics about the learner's performance in association to expected one /email to revisit missed material*
Peer/Group Collaboration	Self-Reported by group members: *email, forums posts* Platform: *many posts in different discussion forums /many visits of different discussion forums / No logins before the collaborative task (e.g., peer-review)* Discussion Forums: *No activity in group forums* Peer-Reviews: *Low scores / Few comments / Repetitive comments*	Process-related Feedback: *deadline extensions (LD changes) / re-arrange groups/ discussion forums prompts /positive-negative exemplars/ Commonly asked questions/ Rubrics/Guides* Self-regulation Feedback: *Notifications / reminders*
Feedback	Self-Reported: *email, forums post* Platform*: No reply from instructors* Discussion Forums: *entries and no received answers* Peer Assignments: *Low/High grading / less time in peer assignments / short and little comments*	Process-related Feedback: *deadline extensions (LD changes) / re-arrange groups/ discussion forums prompts /positive-negative exemplars/ Commonly asked questions/ Rubrics/Guides* Self-regulation Feedback: *Notifications / reminders*
Community Building	Self-Reported: *email, forums post* Platform: *Several days inactive in a row / Few time spent in the course* Discussion Forums: *Low activity (questions, answers) / No replies*	Process-related Feedback: *discussion forums prompts / targeted discussion forums*
Technical Problems	Self-Reported: *email, forums post* Content Pages: *Many visits* Discussion Forums: *High number of posts (or answers) in specific forums*	Process-related Feedback: *discussion forums prompts / targeted discussion forums*
Learning Design	Self-Reported: *email, forums post* Platform: *No or low logins in the last days / reaching a milestone without visiting or submitting connected resources / no visits on milestones /*	Process-related Feedback: */positive-negative exemplars/ Commonly asked questions/ Rubrics/Guides / Online informative tutoring* Self-regulation Feedback: *Notifications / reminders*

5.4. Scenario of FeeD4Mi Application

This section presents an illustrative scenario as an example of how an instructor would use the FeeD4Mi framework, including its process, catalogues, and recommendations for her MOOC.

Sophie is a university teacher preparing a MOOC on translation between English and Spanish. The course consists of eight weekly modules and each module included video lectures, readings, extra resources, discussion forums, individual and collaborative activities. The certificate is issued to those participants completing all the compulsory activities (one per week). The estimated workload is 3 hours per week.

Following the FeeD4Mi process, Sophie starts outlining the course design. She annotates the course modules and the number of compulsory and non-compulsory activities, the number of individual and group assignments and the activity characteristics (e.g., type of activities: open-text assignment, multiple choice quiz, difficulty of activities). She also highlights the connection among videos and the related content material that learners need to visit to be able to comply with the activity objectives. The next FeeD4Mi phase is the reflection on potential learner problems. Given her course, Sophie is afraid that group members will not contribute equally to the joint assignments, which require a lot of elaboration from all the group members (i.e., 5 members per group). After checking the FeeD4Mi catalogues, she also thinks that learners might find the assignments difficult, and they might face platform issues. Considering her limited time, by prioritising the problems, she decides to focus on the problems related to the difficulty of the activities and the collaboration.

After identifying the problems, she checks the related indicators that could help her to detect learners dealing with these problems. From the FeeD4Mi catalogues she selects some relevant indicators for the problems related to difficulty with the activities. Regarding the collaboration problems, since she has not prior experience in collaborative activities in MOOCs, she follows the provided recommendations on which indicators to choose. The selected indicators per problem are the following:

- *Difficult activities*: many visits at the videos of the module, use of maximum number of attempts in quizzes, low score.
- *Absent members/Unfair activity contributions*: length of the contribution (i.e., short text), no activity 2 days before the assignment submission.

In the phase of feedback rules, she sets the following thresholds as triggers for detecting potential struggling behaviours:

- *Difficult activities:* Struggling behaviour 1= In module 2, if learners visit more than 4 times the video material and they do 1 attempt with a score lower than 50%.
- *Difficult activities*: Struggling behaviour 2= In module 4, if learners visit more than 3 times the video material, and they do 2 attempts with a score lower than 50%.

— *Absent members/Unfair activity contributions*: Struggling situation 3= In the group assignment, if there are contributions with less than 5 sentences or if more than 3 (out of 5) group members have not visited the activity page the last 3 days (before the deadline).

Regarding the feedback reactions, she decides to provide additional exercises for the learners struggling with the activities of the first module and additional readings for the learners struggling with the activities of the 4th module. At the same time, when learners achieve more than 90% to such assignments, she will send them immediately a predefined motivational email. Attending to collaboration issues, in case of absent members, she decides to send a reminder to the group members to visit the course and fulfil the assignment. Additionally, she will extend the deadline for the group members who, out of 5 learners, only 3 or less will participate actively. In case of unequal contributions, she will give additional attempts for the next modules quiz to the learners who contributed more than the rest of the group. Figure 5.4 summarized the above process. Specifically, it depicts all the actions that Sophie carried out step-by-step following each of the FeeD4Mi five dimensions.

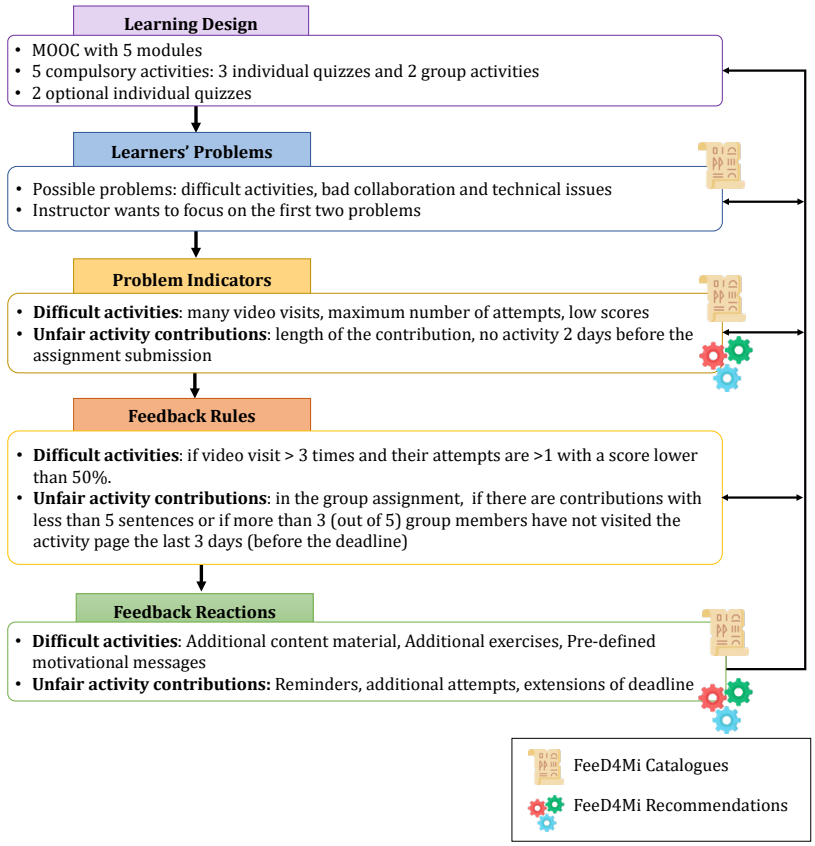


Figure 5.4. Example scenario of the FeeD4Mi process application. The case of Sophie.

5.5. FeeD4Mi Design Guidelines

The last sub-contribution of the current dissertation related to FeeD4Mi regards the provision of design guidelines for the incorporation of the framework into technological tools.

Initially, FeeD4Mi was applied in a paper-based version. The instructors who participated in the first two evaluative studies (see Sections 6.2.1 and 6.2.2) followed the FeeD4Mi steps according to researcher's directions and reflected on the catalogue aspects through post-its of different colours (see Figure 5.5). To foster the FeeD4Mi applicability in real courses we created a set of design guidelines (#CON_2(d)). The FeeD4Mi design guidelines aim at enabling the FeeD4Mi incorporation into tools, so that instructors can automatise the FeeD4Mi process and generate computer-interpretable feedback designs. Additionally, the guidelines aim to support an independent use of the framework without the need of further assistance from the researcher. These guidelines are foreseen to be applicable to any tool that aims to implement the framework. Table 5.5 presents the design guidelines, that emerged from the knowledge developed using the paper-based version of FeeD4Mi during the first two evaluative studies (see Sections 6.2.1 and 6.2.2). In the third DBR cycle, we employed them to develop a web tool, e-FeeD4Mi and thus, evaluate their added value. e-FeeD4Mi implemented FeeD4Mi according to the design guidelines, including its process, catalogues, and recommendations. The third evaluative study served for the evaluation and refinement of the design guidelines through the e-FeeD4Mi application(see Section 6.2.3).

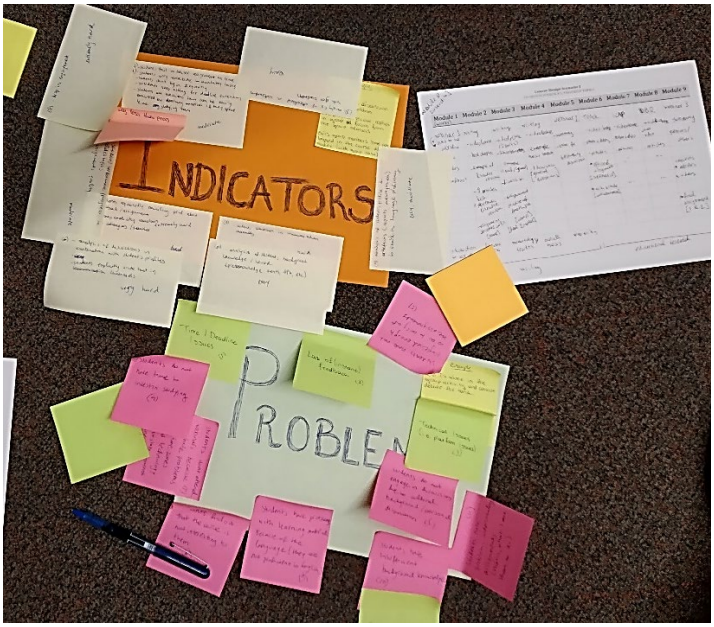


Figure 5.5. The FeeD4Mi process applied in a paper-based approach

Table 5.5. Summary of the design guidelines created to apply FeeD4Mi into tools

N	Design Guidelines
1	To represent each FeeD4Mi dimension via sequential screens
2	To highlight the actual user stage during the FeeD4Mi process
3	To represent digitally the course LD and its characteristics
4	To describe self-reported and monitored-based indicators
5	To provide options for specifying the timing of the feedback intervention
6	To provide the three FeeD4Mi catalogues and recommendations
7	To include the possibility for adding new learner problems and feedback reactions
8	To include hints and explanations for each FeeD4Mi action

Concretely, the generated design guidelines are the following:

1) To represent each FeeD4Mi dimension via sequential screens

The FeeD4Mi process involves 5 sequential phases that require instructor's actions in each of them (see Section 5.3.2). To this end, the digital version of FeeD4Mi is expected to include five different interfaces (one per phase) among which the instructors can navigate. Additionally, the instructors should not be able to advance to the next phases without completing the previous ones. For instance, instructors should not configure feedback reactions without first specifying the potential problems that might happen in the course. On the

other hand, instructors might want to return to a previous phase, in case they want to edit or re-configure decisions taken in previous phases (e.g., addition of new potential problems after viewing the catalogue of indicators). To guarantee the clarity of the FeeD4Mi process and the representation of the five dimensions, we propose the creation of several screens that are organised sequentially based on the process steps.

2) To highlight the actual user stage during the FeeD4Mi process

During the paper-based version of FeeD4Mi, the researcher was guiding the MOOC instructors within each FeeD4Mi dimension. To achieve this possibility, the design guidelines propose the inclusion of a progress bar to the digital version of FeeD4Mi to inform the MOOC instructors about the current stage of the FeeD4Mi process. Figure 5.6 illustrates how e-FeeD4Mi supported this need. With intense colours e-FeeD4Mi highlights the current FeeD4Mi phase that the user is, the completed phases and the pending ones. According to the guidelines, the tool allows the user to move back and forth to the previous and next FeeD4Mi dimensions, respectively, an action foreseen to happen in the paper-version of the conceptual framework.

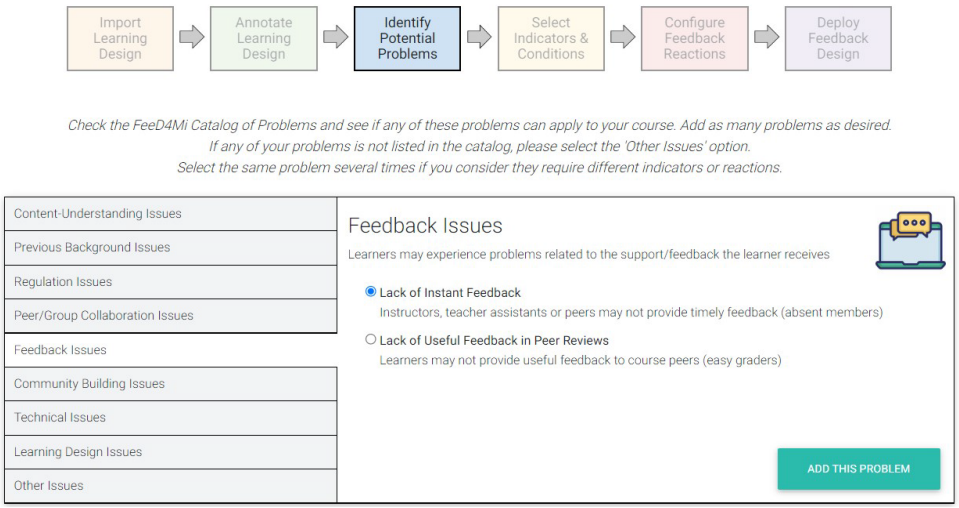


Figure 5.6. e-FeeD4Mi screenshot highlighting the progress bar of the user within FeeD4Mi process.

3) To represent digitally the course LD and its characteristics

One of the requirements of FeeD4Mi is the representation of the course design, so that potential problems, indicators, and feedback reactions can be configured according to the course resources and activities. Therefore, another design requirement is the computer-interpretable representation of MOOCs, including the name and the type of activities. Figure 5.7 depicts the LD outline using FeeD4Mi in a paper-based way (Figure 5.7, top) and the digital LD outlining happened with e-FeeD4Mi (Figure 5.7, bottom). In the concrete case,

e-FeeD4Mi indicates the type of the course resources, e.g., if the visualised resource is a content page (including video or pdf readings), a wiki, a discussion forum, a multiple-choice quiz, or an open-assignment. Additionally, e-FeeD4Mi is able to automatically retrieve the course activities and resources from the MOOC platform. The direct import of the course LD makes the course outlining more manageable for instructors without the time-consuming way followed before with the paper-based version. Within the imported structure, the instructor is enabled to annotate the different interrelations of the course resources (such as which video is related to which quiz) through colour labelling and to indicate with different widgets the level of difficulty of the activities, compulsory/optional and individual/group activities, the critical/milestone resources. Through these options we aim to encourage the reflection on the course LD, as foreseen in FeeD4Mi process.

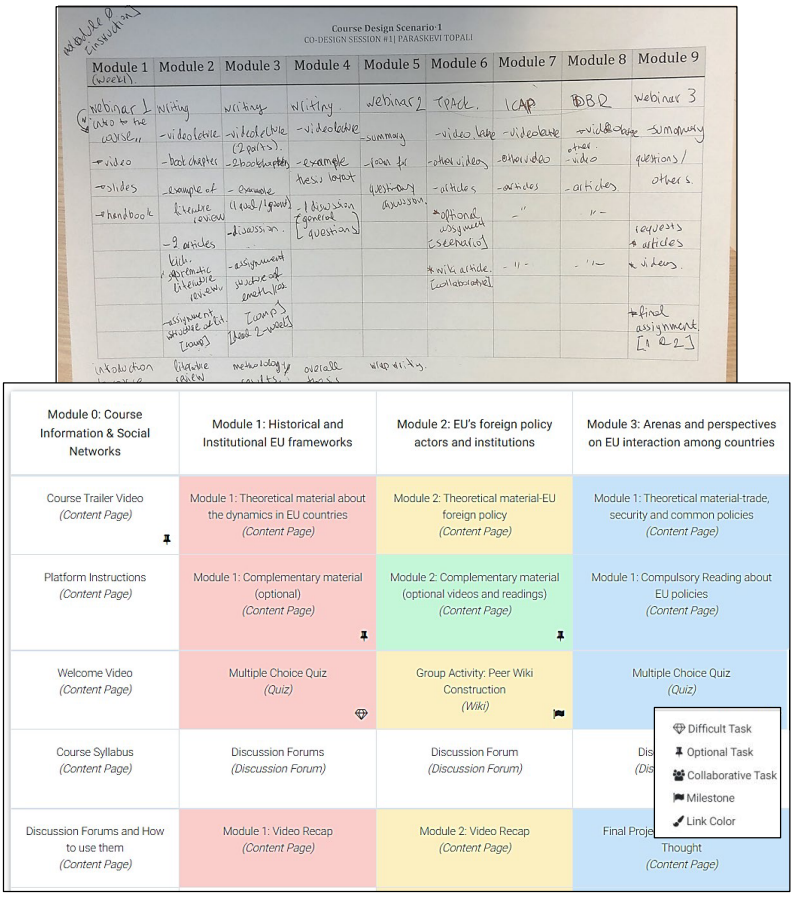


Figure 5.7. Top: Paper-based version of outlining the course LD following FeeD4Mi. Bottom: Digital version of LD representation LD following FeeD4Mi.

4) To describe self-reported and monitored-based indicators

The FeeD4Mi catalogue of indicators includes both self-reported (i.e., emails, posts in discussion forums) and platform monitored (i.e., clickstream data, activity scores) indicators. To guarantee such consideration and facilitate the MOOC instructors to determine different indicators, the digital version of FeeD4Mi should offer the opportunity of specifying self-reported indicators through the creation of special threads in the discussion forums and in the MOOC platform automatically. Figure 5.8 (top) depicts how e-FeeD4Mi represents such option. Additionally, the tool provides the possibility of selecting different monitored-based indicators and associate such indicators with the different course resources (see Figure 5.8, bottom). For instance, if a MOOC instructor considers the score quizzes as an informative indicator, they can further associate such score indicator with the concrete quiz of Module 3, and thus automatize the process of detecting critical learner behaviours that mark under this quiz score.

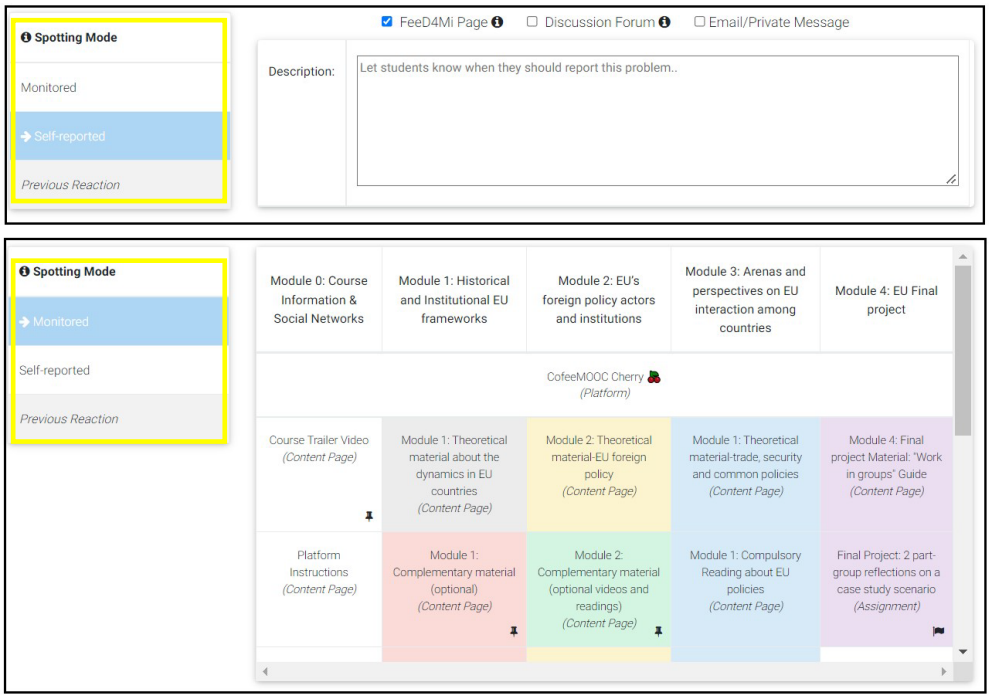


Figure 5.8. Consideration of indicators in e-FeeD4Mi. Top: selection of self-reported indicators. Bottom: selection of monitored-based indicators.

5) To provide options for specifying the timing of the feedback intervention

FeeD4Mi foresees the specification of the intervention timing (i.e., delayed, or immediate). To satisfy that need, when the learner behaviour is complied with the indicators set, the tool that incorporates FeeD4Mi should provide the opportunity of adjusting the intervention time. In the case of e-FeeD4Mi the user can select to deliver the feedback intervention either: i) instantly (i.e., the

feedback will be delivered directly in an automatic manner), ii) after one day (i.e., the feedback will be delivered automatically but after a-day margin, permitting the possible interaction among learners), or iii) when instructor approved (i.e., the feedback will be delivered when instructor enters in the tool and approves the action) (Figure 5.9). Thus, the intervention timing option suggests the MOOC instructors to reflect on the most appropriate timing according to their objectives. For instance, in [Exp_3] we found that many instructors want to solve instantly technical problems, while they tend to wait and thus encourage learner-to-learner interaction for content understanding issues.

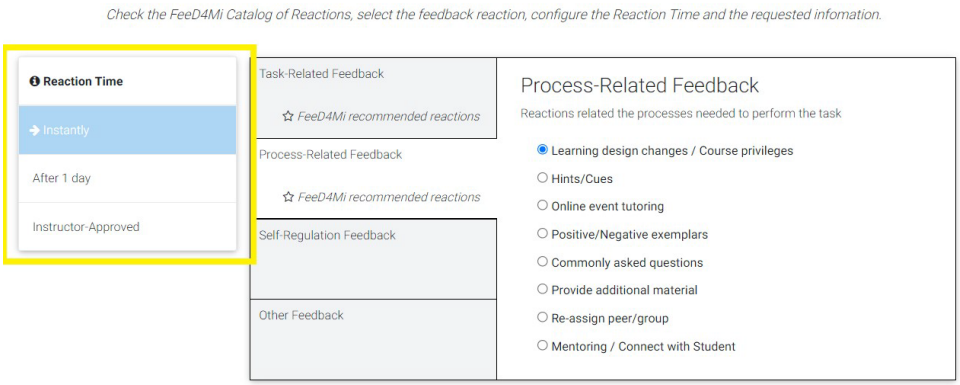


Figure 5.9. Configuration of the intervention timing (see yellow frame) in e-FeeD4Mi.

6) To provide the three FeeD4Mi catalogues and recommendations

As stated at the beginning of the section, the digital version of FeeD4Mi should include the FeeD4Mi catalogues and recommendations. Following the design guidelines, e-FeeD4Mi incorporates the FeeD4Mi catalogues of problems, indicators and feedback reactions and the recommendations ideas presented in the previous sections (see Figure 5.10). The MOOC instructors are able to select and further describe the aspects they find interesting. Multiple learner problems, problem indicators and feedback actions should be chosen Additionally, e-FeeD4Mi provides a list of recommendations of indicators and feedback reactions, based on the previously selected problems. The user can take into account such recommendations and/or select freely other indicators and feedback reactions they consider more suitable.

7) To include the possibility for adding new learner problems and feedback reactions

As expected by FeeD4Mi process itself, in the digital version of FeeD4Mi the users should be able to personalise their feedback designs by suggesting additional learner problems and feedback reactions from scratch. Thus, if the suggested FeeD4Mi catalogue options do not fit the instructors' needs, the

users can add new problems, associate them with the given indicators (that are predefined based on the MOOC platform) and create further feedback reactions as well. Figure 5.11 illustrates e-FeeD4Mi attending to that issue.

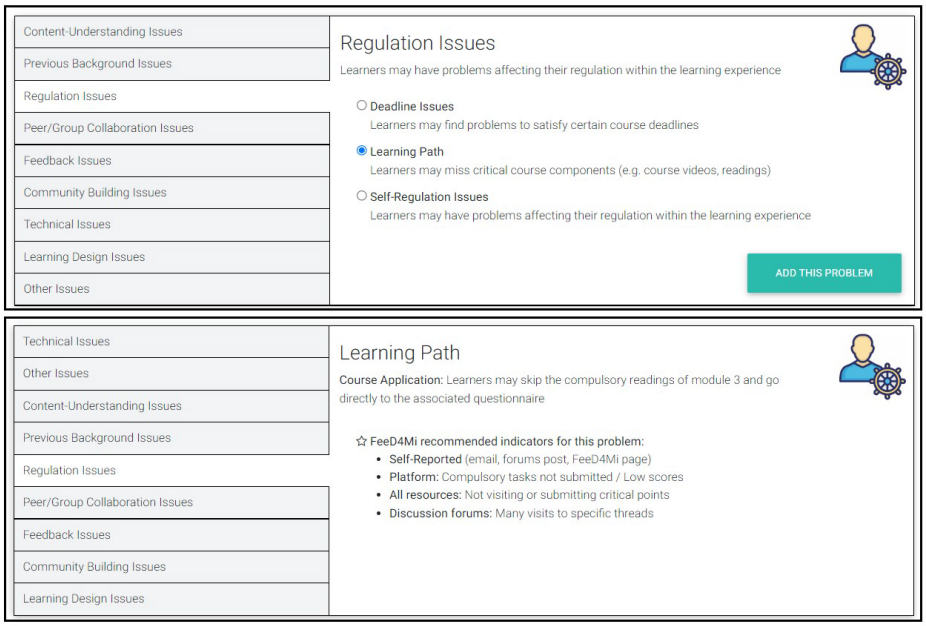


Figure 5.10. Representation of the catalogues and recommendations in e-Feed4Mi. Top: Potential learners' problems related to regulation issues. Bottom: Recommended indicators.

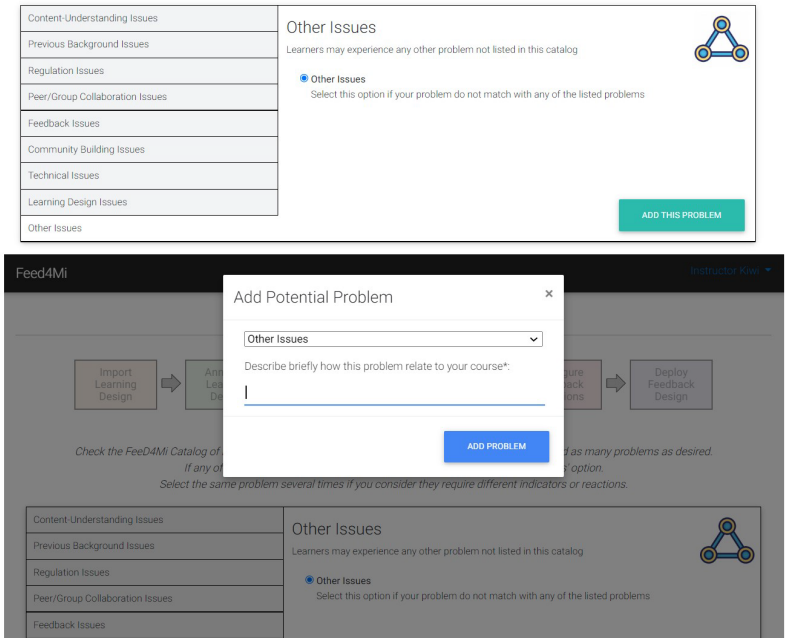


Figure 5.11. Example of additional aspects (e.g., potential problems) that can be inserted by instructors.

8) To include hints and explanations for each FeeD4Mi action

Finally, to facilitate the independent use of the tool, the digital version of FeeD4Mi should provide hints and explanations for each one of the required actions. As stated before, instructors should use the framework without the help of the researcher as guide. Hence, we considered that the provision of hints and explanations would permit this desired independent use. Figure 5.12 displays some examples of the hints and explanations provided in e-FeeD4Mi. The hints emerged from the conducted exploratory and evaluative studies, where we tested the conceptual framework with MOOC instructors.

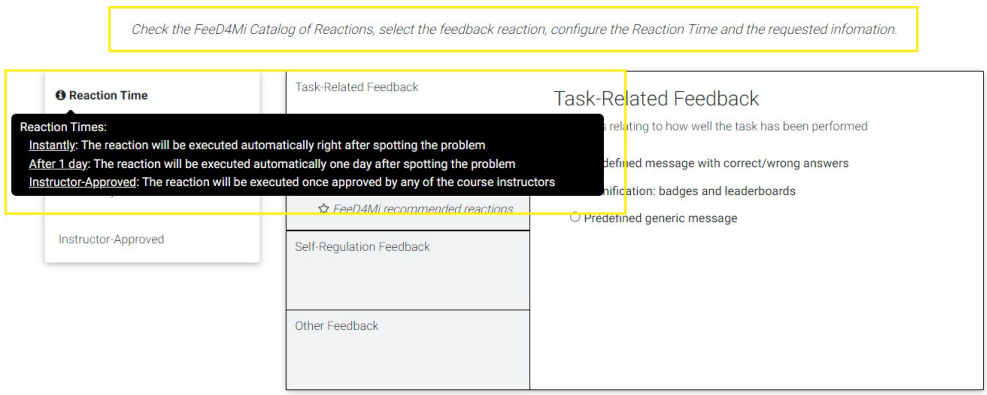


Figure 5.12. Hints and explanations to facilitate the independent use of FeeD4Mi in e-FeeD4Mi.

5.6. Conclusions

This chapter presented the second contribution of the current dissertation, addressing the need of helping instructors to: a) shape personalised and contextualised feedback interventions in MOOCs [OBJ_2], and b) make manageable (in terms of time) the design of feedback interventions [OBJ_3]. Building on these two objectives, this chapter discussed four LA proposals that support instructor-led LA-informed feedback (see Section 5.2). L.I.M.E. (Burgos, 2013), OnTask (Pardo et al., 2018), SRES (Liu et al., 2017) and MOOClet framework (Reza et al., 2021) permit instructors to select and fine-tune indicators defining critical learner behaviours and to intervene accordingly with automated or semi-automated feedback. Nevertheless, these proposals do not support a definition of the rule conditions considering elements of the course design (e.g., to specify the assignment difficulty, the compulsory/optional tasks). Additionally, they do not provide explicit guidance to instructors in reflecting on the LA information, the course design, and the various feedback-related aspects to shape personalised interventions for MOOCs. According to Mangaroska & Giannakos (2019), the connection of LA and LD itself requires more guidance. Additional guidance would be

required on how to design feedback for large scale. Last but not least, from the suggested models, only the proposal from Reza et al. (2021) was designed taking into account the specific characteristics of MOOCs. The context of MOOCs, supporting courses for a massive and diverse learner population, should be considered explicitly, since different learner problems can be triggered due to it.

Addressing the limitation of lack of guidance of the abovementioned proposals, this chapter has presented FeeD4Mi, a five-dimension conceptual framework. FeeD4Mi consists of a five-dimension conceptual structure, a process, a set of catalogues and a set of recommendations, aimed to guide step-by-step MOOC instructors in connecting the course LD with LA indicators and in reflecting on feedback aspects (such as the feedback timing, the feedback type) to design personalised feedback interventions. Addressing the limitation of lack of definition of feedback rules given the LD, FeeD4Mi involves instructors in the reflection and outline of their own MOOC to contextualise the feedback strategies with the course LD. Addressing the limitation of considering the specific characteristics of MOOCs, FeeD4Mi includes a catalogue of common learner problems that often occur in MOOCs and a catalogue of indicators supported by various MOOC platforms to facilitate instructors' reflection. Additionally, the current dissertation proposes a set of design guidelines aimed at supporting the FeeD4Mi implementation into web tools and, thus, to render manageable feedback design through the automatic enactment of computer-interpretable rule-based strategies. The following chapter describes the evaluation of the FeeD4Mi proposals under four studies in regard to the posed research objectives (see Chapter 6).

Chapter six

FeeD4Mi Evaluation

Summary: The current chapter delves into the **FeeD4Mi evaluation** according to the dissertation objectives raised in Chapter 1. The evaluation consisted of **four studies** (two formative and two summative), one per DBR cycle (see Section 1.3). The studies were carried out in different contexts (e.g., co-design sessions workshops with experts, application in real courses) and involved different participants (e.g., MOOC experts, instructors). The results illuminated the accomplishment of the second and third dissertation objectives and indicated directions for future research regarding the design of LA-informed feedback in MOOC environments.

This Chapter is based on the following publications:

Topali, P., Ortega-Arranz, A., Martínez-Monés, A., Villagra-Sobrino, S., Asensio-Pérez, J. I., & Dimitriadis, Y. (2021). Identifying Learner Problems Framed within MOOC Learning Designs. In: *Proceedings of 29th International Conference on Computers in Education Conference,* ICCE 2021. pp. 297–302.

Topali, P., Ortega-Arranz, A., Chounta, I. A., Asensio-Pérez, J. I., Martínez-Monés, A., & Villagrá-Sobrino, S. l. (2022). Supporting instructors in the design of actionable feedback for MOOCs. In: *Proceedings of IEEE Global Engineering Education Conference*, EDUCON2022. pp. 1881-1888.

Topali, P., Cobos, R., Agirre-Uribarren, U., Martínez-Monés, A., & Villagrá-Sobrino, S. l. (2022). Co-Design and Evaluation of Instructor-led LA-informed Feedback in MOOCs. *Under Review.*

Ortega-Arranz, A., **Topali, P.**, Asensio-Pérez, J.I., Villagrá-Sobrino, S.L., Martínez-Monés, A., Dimitriadis, Y. (2022). e-FeeD4Mi: Automating Tailored LA-Informed Feedback in Virtual Learning Environments. In: *Proceedings of the 18th Conference on Technology-Enhanced Learning* Springer, Cham. pp. 477-484

6.1. Introduction

A DBR methodological approach foresees an iterative testing and refinement of the proposed contributions to meet the final objectives (Amiel & Reeves, 2008). Accordingly, the design and development of the FeeD4Mi framework concerned an iterative process, evolving constantly during each DBR cycle. We carried out four evaluation studies, one in each DBR cycle, which revealed new requirements that supported the FeeD4Mi enhancement (see Figure 6.1). All studies had a degree of both summative and formative component. However, in this chapter we will classify the four studies according to the most predominant component they served. Thus, two of the studies supported more a formative evaluation, i.e., the refinement of the framework and the consideration of emerging needs as MOOC instructors used FeeD4Mi. Likewise, two studies served more for a summative evaluation, i.e., the assessment of the extent to which the proposed framework complied with the thesis objectives:

- to help instructors to shape personalised and contextualised feedback interventions in MOOCs (OBJ_2),
- to make manageable the design (and provision) of feedback for MOOC instructors (OBJ_3).

Concretely, the first evaluation (see Section 6.2.1) took place at the first DBR cycle and served for assessing FeeD4Mi in its early stage and for understanding instructors' needs while using the framework. The second evaluation (see Section 6.2.2) aimed at assessing the refined version of the framework and its application into an authentic MOOC scenario. The third and the fourth evaluative studies (see Sections 6.2.3 & 6.2.4) focused on how to support MOOC instructors in the manageable use of FeeD4Mi.

The rest of the chapter is organised as follows. Section 6.2 presents the context of each of the four evaluative studies carried out during the DBR process. Section 6.3 outlines the methodology that guided the evaluations. Section 6.4 provides a synthesis of the obtained results and Section 6.5 discusses the findings. Finally, Section 6.6, presents the main conclusions raised from the evaluative studies.

Figure 6.1. Overview of the studies involved in the evaluation of FeeD4Mi.

6.2. Evaluative Studies

This section briefly presents the context and objective of each study separately. The overarching methodology and a synthesis of the obtained results are discussed later.

6.2.1. First Evaluative Study [EV_1]

During the first DBR cycle, we aimed to evaluate with MOOC instructors the preliminary version of: a) the FeeD4Mi process (CON_2a) and b) the catalogues of learners' problems and problem indicators (CON_2b). This evaluative study (i.e., [EV_1]), followed a co-design approach with three instructors delivering two different MOOCs. The study lasted from February to May 2020 and had a formative character (Fraenkel et al., 2012). Specifically, the study aimed at assessing the completeness and added value of the FeeD4Mi catalogues and process (given the FeeD4Mi version at that moment) and at identifying aspects for improvement. The entailed co-design sessions involved two authentic courses, denoted as *Case#A* and *Case#B* in this dissertation. Concretely:

- *Case#A* regarded a MOOC about EU-Russia relations and policy actions. The course was offered by the University of Tartu, Estonia, and was offered in a Moodle-based platform. It spanned five weeks, and each module included video lectures and readings (optional and mandatory ones), extra resources, wikis, discussion forums and individual activities (i.e., quizzes, assignments, projects). Course certificates were issued to those participants completing all the compulsory activities with a minimum of 51 grading points at the end of the course. The estimated participant workload was 7-11 hours per week.
- *Case#B* regarded a MOOC introducing web development with HTML5, CSSS3 and JavaScript. The course was offered by University of Patras and deployed in Mathesis platform[13]. It spanned five weeks and each module included video lectures, discussion forums, optional self-assessment individual activities (i.e., quizzes) and compulsory peer reviewed assignments (i.e., projects). One instructor was responsible for delivering the course. The learners' workload was estimated in 14 hours per week.

[13] Mathesis (https://mathesis.cup.gr/) is a national Greek platform for online courses in Greek language.

In [EV_1] we applied the preliminary version of FeeD4Mi defined at the first DBR cycle. Through each co-design session, participants (i.e., two instructors in Case#A and one instructor in Case#B) followed the first steps of the FeeD4Mi process: (1) outline their course design, (2) reflect on potential learner problems that might happen with the course components, and (3) identify the indicators (i.e., learners' trace data) and to define behaviours of potentially struggling learners under the previously selected problems. The process did not involve the last step related to the selection of feedback reactions, because this dimension was in an immature level. The procedure was the same for the reflection of potential learners' problems and indicators. More concretely. firstly, we asked the participants to think of problems and indicators, without providing them with the FeeD4Mi catalogues. Afterwards, the researcher provided to the participants a catalogue of recurrent learners' problems happening in MOOCs, and participants assessed whether they elicited new ideas about potential problems and/or indicators. Therefore, we could further understand the extent to which the catalogue supports the problems mentioned by instructors, and the extent to which the catalogue helped them to reflect on potential problems that they did not consider alone but after all are applicable to their courses.

Each co-design session lasted 2h approximately. Case#A was held face-to-face, with participants to use the FeeD4Mi catalogues through post-its. Case#B was held online due to COVID-19 restrictions. To facilitate the data collection and the instructor's reflections around the FeeD4Mi process we employed web tools, such as Padlet [14]. Figure 6.2 depicts two moments of the FeeD4Mi use during the two co-design sessions.

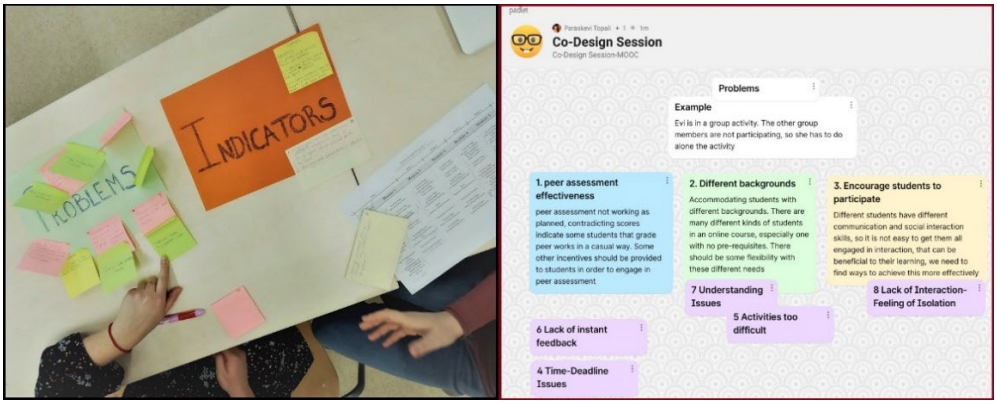


Figure 6.2. MOOC participants applying FeeD4Mi during the evaluation study. Left: Case#A, face-to-face. Right: Case#B, online.

[14] Padlet (https://el.padlet.com/). Last access: June 2022

6.2.2. Second Evaluation Study [EV_2]

In second DBR cycle, we aimed at studying the whole life cycle (i.e., course design, course enactment, post-course aftermath) of feedback design and implementation supported by FeeD4Mi in an authentic MOOC context. Thus, we conducted a study, i.e., [EV_2], applying the complete version of FeeD4Mi in a MOOC to evaluate the framework in a real case and assess its usefulness, its manageability and its impact as perceived by the course stakeholders (i.e., instructor and learners).

This study was conducted from December 2020 to November 2021 (see Figure 6.3) and regarded a summative evaluation (Fraenkel et al., 2012). Specifically, we examined the enhanced version of FeeD4Mi as resulted from the previous evaluation, i.e., [EV_1], and the outcomes derived from its application in an actual MOOC. Nevertheless, the study had as well a formative purpose examining the usefulness of the 'feedback reactions' catalogue, which has not been examined before. The course was a self-paced MOOC about the development of web applications based on HTML, CSS, Python, JSON, JavaScript, and Ajax. The course lasted five weeks and each weekly module included content material in the form of videos and web pages, various types of evaluation activities and platform-based discussion forums. After this study the course remained active, nevertheless, the data examined for [EV_2] (e.g., learners' trace data, instructor's course activity) regarded the period from September 2021 to November 2021.

The concrete MOOC was purposefully chosen, because the instructor and a developer were using were involved in the redesign of an existing LA-tool, edX-LIMS, that enabled us to examine the application of semi-automatic feedback interventions created with FeeD4Mi in an actual case. edX-LIMS consists of two dashboards (a Learner and an Instructor one) and was available to the MOOC instructor during the course enactment to provide feedback based on learners' trace data and course activity (Cobos & Soberón, 2020). During our evaluative study, the use of FeeD4Mi led to a redesigned version of the tool, edX-LIMS+ to support the new metrics and conditions selected after the use of FeeD4Mi. Specifically, the redesign regarded the inclusion of: a) two tables at the Instructor dashboard to support the created rules based on the selected FeeD4Mi indicators, and b) a space for dialogue to Learner dashboard, where learners could confirm or reject that they are experiencing a problem and specify further about the usefulness of the provided support.

[EV_2] involved three temporal happenings, i.e., the course design and implementation, the course enactment, and the post-course reflections:

i. *The course design and implementation*: the first happening consisted of 5 co-design sessions with the leading researcher, the MOOC instructor, and the tool developer. In this happening, the instructor used the FeeD4Mi framework, including its catalogues and process, to reflect on: (a) potential problems that the learners might experience, (b) indicators based on learners' trace data provided by the system that could permit the detection of struggling learners and (c) the feedback reactions to help such learners overcome their problems. The sessions took place virtually from December 2020 to May 2021 and lasted 1:30h each. The final product of this happening was a set of feedback decisions, including potential learners' problems, indicators to identify them and feedback reactions. These decisions served for the redesign of edX-LIMs to include the selected conditions.

ii. *The course enactment*: the second happening regarded the enactment of the under-study MOOC, where we applied the feedback decisions taken in the previous happening and we gathered data from the course learners and instructor. The collected data are presented in Section 6.3 and examined the impact of the feedback decisions created with FeeD4Mi. This happening lasted from September to November 2021.

iii. *The post-course reflections*: the third happening involved the collection of the instructor's and tool developer's perceptions about their experience with FeeD4Mi (i.e., manageability and usefulness of the framework). This happening took place online during the last week of November 2021.

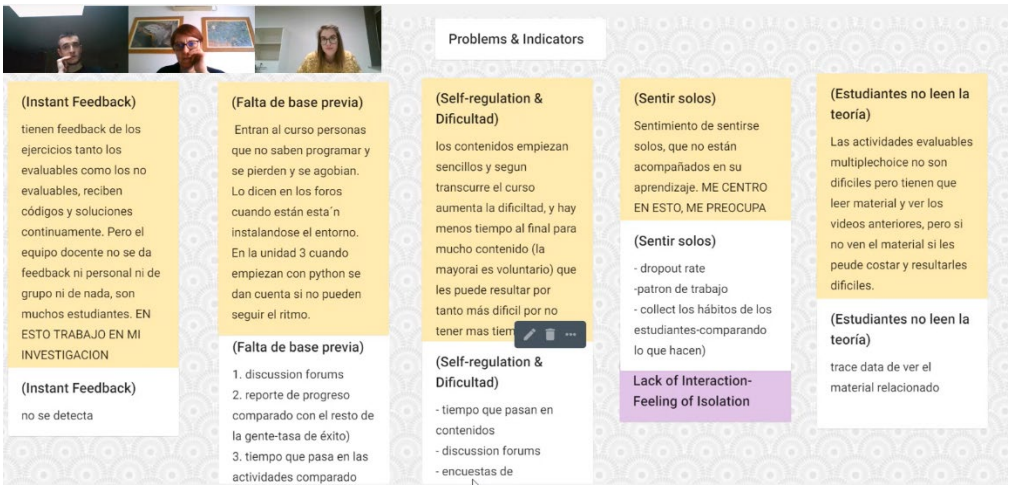


Figure 6.3. Screenshot of the FeeD4Mi process during [EV_2].

6.2.3. Third Evaluation Study [EV_3]

The findings from [EV_2] (see Section 6.4) indicated the need of providing additional support to MOOC instructors when using FeeD4Mi to avoid its time-consuming process and to automatise the feedback interventions. Such findings are aligned with the evidence gathered in [Exp_3] (see Section 3.3.2), where the MOOC instructors reported the need of technological tools, apart from conceptual ones, to automatically scale feedback provision in MOOCs. Consecutively, within the third DBR cycle, we examined how the FeeD4Mi framework can support MOOC instructors in the design of feedback practices via e-FeeD4Mi. To do so, we carried out the third evaluation study [EV_3], having a formative purpose; [EV_3] served for the enhancement of FeeD4Mi and helped us to refine the e-FeeD4Mi features and functionalities, as proposed by the participants.

[EV_3] took place within the context of a 3-hour workshop with 11 MOOC stakeholders (i.e., instructors, researchers, learners). The selection of the participants followed a convenience sample approach, given the availability of the stakeholders to participate at the evaluation and their prior experience with MOOCs (Fraenkel et al., 2012). During the workshop, we divided the participants into groups of 3 or 4 people, including one facilitator as guide throughout the evaluation. The workshop consisted of the following sequential phases:

i. *In the first phase*, each group obtained a different MOOC outline with information about the course context, the type of activities (i.e., quiz or assignment, collaborative or individual, optional, or compulsory), the connections among the different course resources (i.e., which video is related with which activities) and the course duration. Building on such information, we asked each group to design feedback for potential struggling learners according to the FeeD4Mi process (i.e., detecting potential learner problems, associating them with indicators, deciding feedback interventions). During that phase, the participants were not supported with the FeeD4Mi catalogues.
ii. *In the second phase*, we asked participants to configure their previous MOOC designs using e-FeeD4Mi. Since e-FeeD4Mi included the framework catalogues, participants were able to enhance their designs with additional suggestions or create new feedback designs from scratch.
iii. *In the last phase*, participants reflected on their experience with FeeD4Mi and e-FeeD4Mi and answered a subsequent questionnaire.

The workshop took place on July 2021, and it was held online, due to COVID-19 restrictions. We had 6 groups of participants, and each group received a different course outline and description based on existing MOOCs. Providing a course outline is one of the study limitations, since the participants were not familiarised with the provided designs. Apart from the web tool, the workshop tasks were supported by the Mural application[15], that permitted the synchronous interaction among group members. Figure 6.4 depicts an example of the feedback designs created in Mural App.

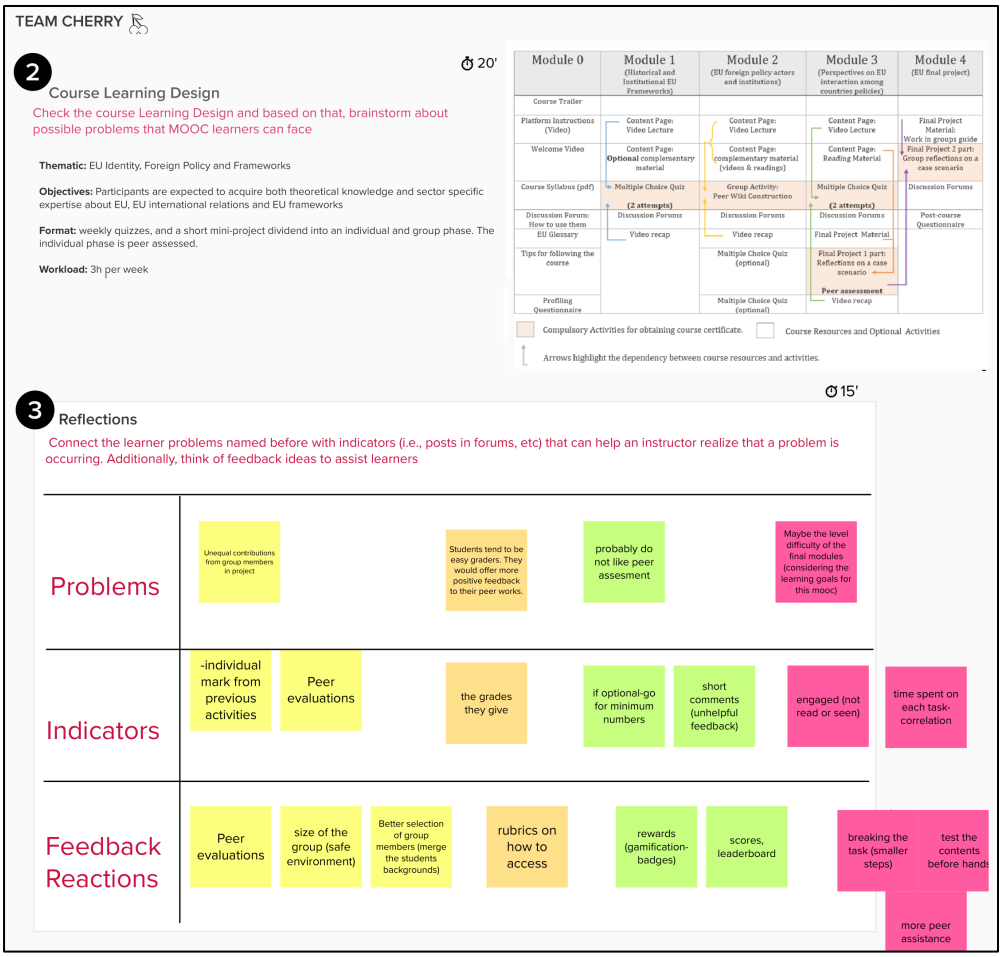


Figure 6.4. Feedback designs created following the FeeD4Mi process in [EV_3].

[15] Mural App (https://www.mural.co/). Last access: August 2022

6.2.4. Fourth Evaluation Study [EV_4]

The last cycle of this dissertation focused on understanding the extent to which FeeD4Mi supports instructors to design personalised and timely feedback in MOOCs (OBJ_2) in a manageable way (OBJ_3). To accomplish such need, we carried out a summative evaluative study, i.e., [EV_4], with 6 MOOC instructors from different institutions and with different backgrounds. During [EV_4] we used the latest version of FeeD4Mi implemented into e-FeeD4Mi. This subsection briefly presents the last evaluation.

[EV_4] took place virtually from January to February 2022. The evaluation consisted of an online experimental set up with 6 instructors (one session per instructor) with experience in MOOC teaching. Each session with each participant lasted approximately 1:30h and involved the following sequential happenings:

i. *Prior to feedback design:* The first happening consisted of gathering participants' profiling information (experience on MOOC teaching). Additionally, we asked participants to describe the feedback strategies regularly used at their MOOCs. During this happening participant did not use the conceptual framework. This approach was expected to help us understand the extent to which FeeD4Mi can represent the feedback practices of MOOC instructors without being biased by the options offered from the framework. The first happening lasted around 15 minutes.
ii. *Feedback design with participants' own course design*: During the second happening participants were introduced to FeeD4Mi and e-FeeD4Mi. We asked participants to create feedback interventions applied to their own MOOC designs using e-FeeD4Mi. The objective of this happening was to understand the extent to which FeeD4Mi can satisfy instructors' needs and to which e-FeeD4Mi can represent the feedback interventions designed by MOOC instructors. The second happening lasted one hour and, among others, we employed a "think aloud protocol", where we asked the participants to express their opinions and reflections throughout the experience.
iii. *After the feedback design*: The third happening involved a 15-minutes reflection, during which participants completed two questionnaires regarding their experience with the framework components, the e-FeeD4Mi usability (through SUS questionnaire (Brooke, 2013)), and e-FeeD4Mi potential adoption (through Net Promoter Score (Reichheld, 2003)).

Figure 6.5 depicts one MOOC instructor interacting with e-FeeD4Mi during the online evaluation. On the left: the participant is sharing his screen permitting us to observe his interaction with the framework and the tool. On the right: the participant is explaining his actions.

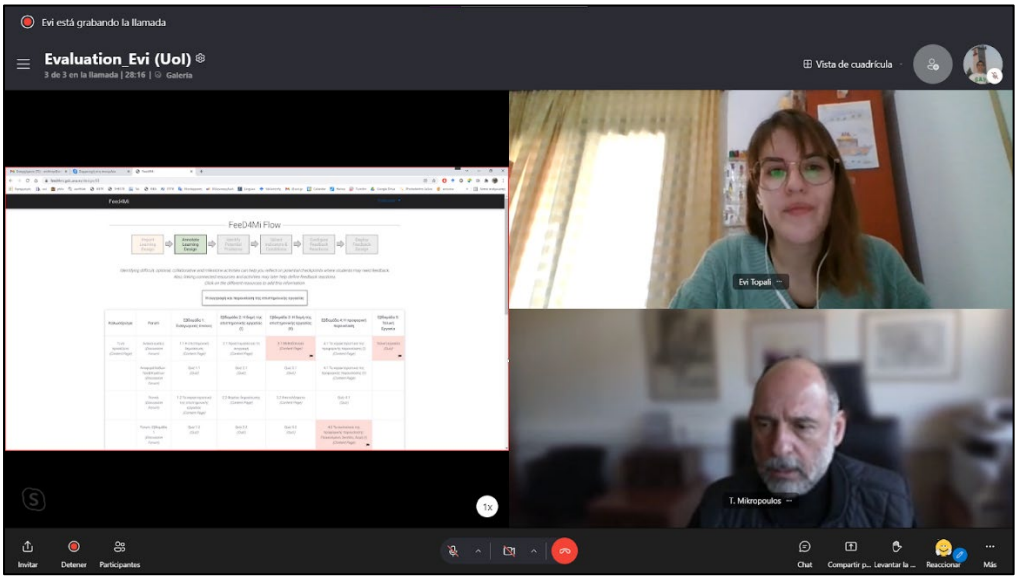


Figure 6.5. Screenshot of the [EV_4], during which a MOOC instructor while creating feedback designs with e-FeeD4Mi.

6.3. Methodology

The following overarching research question directed the evaluative studies: "*How can FeeD4Mi support instructors in the design and provision of personalised LA-informed feedback in MOOCs?",* which concretizsed the general question of this dissertation, i.e., "*How to support instructors in the design and provision of personalised LA-informed feedback in MOOCs?"*. To better answer the research question in each evaluative study, we followed the anticipatory data reduction process (Miles & Huberman, 1994) subdividing the research question into concrete topics. Figure 6.6 presents the topics under which the RQ was subdivided, and Figure 6.7 shows the informative questions considered under each topic and their relationship with #OBJ_2 and #OBJ_3 of the current thesis.

Topics	Description	Evaluation Studies			
		EV_1	EV_2	EV_3	EV_4
Catalogue Completeness	The FeeD4Mi ability to represent the instructors' decisions regarding the design of feedback strategies	X	X	X	X
Usefulness	The added value of the FeeD4Mi catalogues, process, and recommendations in the design of feedback strategies	X	X	X	X
Feedback Impact	The impact of the feedback interventions designed using FeeD4Mi to learners and instructors		X		
Perceived Workload	The manageability of FeeD4Mi, as perceived by the instructors, according to instructors' time and workload constraints		X		X
Perceived Usability	The perceived usability of e-FeeD4Mi			X	X

Figure 6.6. Topics addresses by the four evaluation studies.

Specifically, we evaluated FeeD4Mi uncovering the following topics:

- *Catalogue Completeness:* Catalogue completeness refers to the FeeD4Mi representation of the instructors' decisions during the feedback design. FeeD4Mi provides three catalogues for learners' problems, indicators, and feedback reactions. We deem that the more completed these catalogues are, the more effective they would be to assist MOOC instructors with ideas about their feedback decisions.
- *Usefulness:* This topic refers to the FeeD4Mi added value for the design of feedback strategies. FeeD4Mi consists of three catalogues, a process, and a set of recommendations with the objective of guiding MOOC instructors in the design of feedback strategies. Evaluating the usefulness of these elements, as perceived by the MOOC instructors, will permit us to understand the extent to which FeeD4Mi supports the design of instructor-led personalised feedback interventions. According to Dagnino et al. (2018), instructors' tend to use tools (either conceptual or technological) given their usefulness.
- *Feedback Impact:* FeeD4Mi aims at helping instructors in creating feedback strategies to detect concrete learner cohorts and deliver targeted interventions accordingly. We consider essential to assess the effect of these feedback strategies on MOOC learners and MOOC instructors. In other words, are the feedback strategies successful in supporting the identification of learners potentially struggling? To what extent the feedback interventions satisfy the learners' needs? To what extent do they satisfy the MOOC instructors' desire in delivering personalised feedback?

- *Perceived Workload:* According to Dagnino et al. (2018), the workload that a tool (either conceptual or technological) adds to instructors' teaching practices affects its potential adoption. Under the same prism, we considered it crucial to examine the manageability of FeeD4Mi and e-FeeD4Mi in terms of time and workload to MOOC instructors.
- *Perceived Usability:* The design guidelines (CON_2(d)) proposed to support the implementation of FeeD4Mi into web tools, led us in the creation of e-FeeD4Mi. Usability is a factor directly related to the manageability of the tool and its use and potential adoption by the MOOC instructors. According to Dagnino et al. (2018), a tool's usability affects its potential adoption. Thus, we find it important to evaluate the use of e-FeeD4Mi in practice and the improvement it may require in digitally representing and managing instructor-led feedback strategies for massive contexts. This way we can examine the usefulness of the design guidelines.

The four evaluative studies followed an interpretive research approach (Creswell, Shope, Clark, & Green, 2006). To ensure a deeper comprehension of the FeeD4Mi use into the different cases, we involved a variety of informants and data gathering techniques (see Figure 6.8). A brief description of each data gathering technique is provided in Table 1.1 (see Section 1.3). The questions employed during the evaluative studies (in questionnaires, interviews, wiki diary etc.) to address the abovementioned topics are displayed in Appendix D. Informed consent was obtained from participants the study before conducting each study (see consent form in Appendix D).

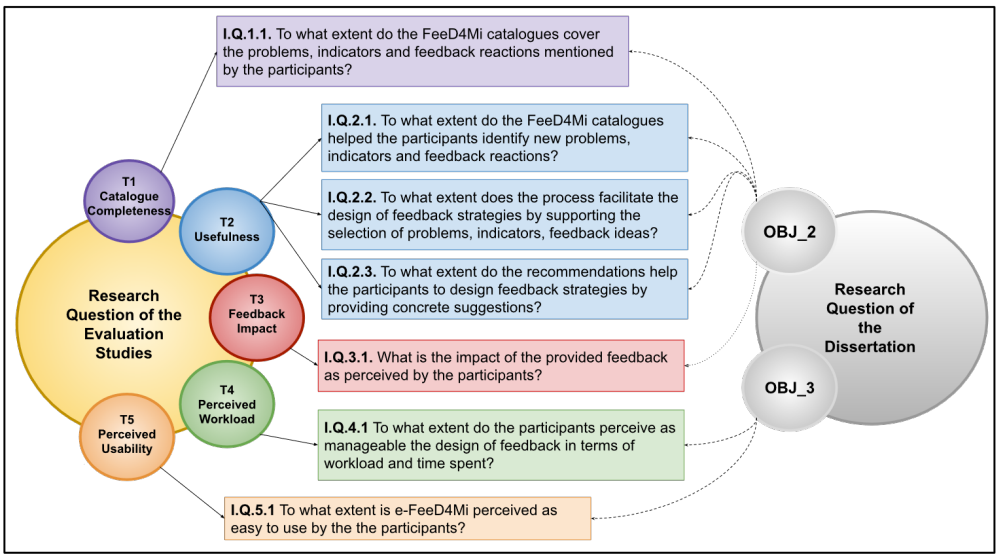


Figure 6.7. Informative Questions addressed in this dissertation related to the objectives 2 & 3.

To ensure the credibility and transferability of the evaluative studies, we employed the following strategies (Guba, 1981; Twining et al., 2017): (a) data triangulation collecting data from different informants, different data sources, and at different time periods of time, (b) investigators triangulation by involving two or more researchers in the data collection and analysis of the coding results, (c) member checking of the findings and their interpretation with the study participants, and (d) provision of thick descriptions of the study context.

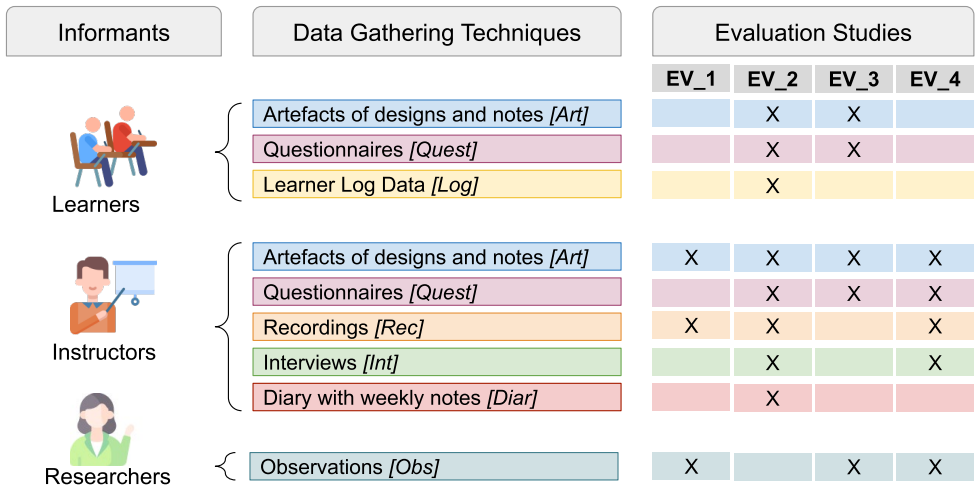


Figure 6.8. Connections among the data gathering techniques and the evaluative studies.

6.4. Results

This section describes the main findings associated to the five topics mentioned in Figure 6.6.

6.4.1. Results: Catalogue Completeness

Catalogue completeness was evaluated during the four evaluation studies. To analyse the FeeD4Mi catalogue completeness we studied the extent to which the FeeD4Mi catalogues could cover the problems, indicators and feedback reactions mentioned by the participants before being exposed to them. In practice, we asked instructors about the feedback strategies they regularly apply at their courses.

Table 6.1 illustrates the percentage of problems supported by the catalogues in each evaluation. While this numeric information can give us a general overview of the completeness level of the catalogues, further analysis

is needed to understand the problems and the associated reasons for those not supported. This analysis is presented below under each evaluative study.

Table 6.1. Catalogue completeness during the evaluative studies with the percentages of the aspects covered by FeeD4Mi and the total number (i.e., N) of the reported aspects by the participants.

Evaluative Studies	Participants	Learner Problems	N	Problem Indicators	N	Feedback Reactions	N
[EV_1]	3	55.5%	9	73.6%	18	-	-
[EV_2]	2	50%	2	77.7%	9	100%	2
[EV_3]	11	55.5%	36	67.4%	43	61.9%	21
[EV_4]	6	80%	5	100%	3	83.3%	6

Evaluative Study 1 [EV_1]

As stated above, [EV_1] evaluated a first version of FeeD4Mi assessing the completeness of the learners' problems and indicators. During this study, the three instructors reported a total number of 9 potential learners' problems. The instructors from Case#A (i.e., EU-Russia relations MOOC) focused more on content-related problems (e.g., activity difficulty, challenges on academical writing in assignments), and lack of communication skills. The instructor from Case#B (i.e., Programming MOOC) focused more on problems related to the peer interaction that might occur in discussion forums and peer assessment issues. After analysing such problems, we found that FeeD4Mi already included 5 of those. However, the following problems were not covered by FeeD4Mi: learners' familiarity with the course platform, learners' different backgrounds (associated to course contents, quizzes, and assignments), and lack of proper interaction among peers.

Regarding the indicators, participants identified 18 indicators as hints alerting of a possible learners' problem. FeeD4Mi considered 14 of them, while 4 were new. The non-included aspects are related to features that require content analysis for their interpretation, such as the analysis of the learners' submitted work or post-course questionnaire analysis and some specific indicators such as posts of participants in wrong threads of forums.

Evaluative Study 2 [EV_2]

[EV_2] evaluated the first complete version of FeeD4Mi assessing the completeness of all the catalogues. During the course design, and following the FeeD4Mi process, the two participants anticipated two learners' problems as probable to happen, i.e., "lack of previous knowledge" and "learners missing resources of their learning path". FeeD4Mi included the former and did not

include the latter one, which was related to the self-paced nature of the MOOC and was considered beforehand.

Attending to the indicators, [EV_2] participants reported 9 indicators that could possibly alert them about the selected learners' problems (e.g., activity scores, forum entries/replies). Out of such indicators, only 2 were not included in the framework (22.22%) and regarded course particular resources, i.e., a survey that the learners had to fill out at the middle of the course to gather their insights up to that point and some platform notifications. With respect to feedback reactions catalogue, participants reflected on two possible ways of supporting learners', i.e., sending predefined motivational messages and providing more attempts to course activities. Both aspects were supported by the FeeD4Mi catalogues (see Table 5.3).

Evaluative Study 3 [EV_3]

During [EV_3], participants reported 36 potential learner problems that may require specific attention based on the given MOOC scenarios. FeeD4Mi supported 20 out of 36 problems (55.5%), mainly related to content understanding, peer collaboration and feedback issues. 6 of these 20 problems, one about content-related issues and the rest of them about collaboration aspects, showed that FeeD4Mi categories required a more detailed description to be more accurate. For instance, while FeeD4Mi includes a general category on "peer collaboration" problems, it lacked more concrete issues under such category, such as "*the unequal contribution on group assignments*" [Art] or "*the fair evaluation of peer assignments*" [Art]. The framework lacked 16 reported problems, many of which were related with the LD of the particular case (n=10). For example, participants reported issues regarding "*the design of only mandatory assignments which may decrease the course interest*" [Art]. Therefore, these 10 issues regarded a different type of problem than the ones FeeD4Mi already included. It is worth to mentioned that, in the step of reflecting on learners' problems, some participants proposed several aspects (n=8) that we did not consider them as problems, since they regarded indicator ideas or general comments. Probably these proposals occurred due to participants misconceptions, fact that a facilitator observed, i.e., "*I noticed some misinterpretations or misconceptions between participants' statements"* [Obs]. These misinterpretations suggested the need of additional guidance and explanations when using the FeeD4Mi catalogues.

Participants stated 43 indicators, with 29 of them to be supported by FeeD4Mi. Examples of such indicators regarded activity scores, forum interaction (i.e., entries and replies) or learners' clickstream activity. FeeD4Mi did not include 10 indicators, e.g., "*number of learners at a concrete checkpoint*

set by instructor", and "*number of off-topic words in forum posts*" [Art]. From the rest of the indicators (n=4), 2 were not precise enough (e.g., "the students' LA activity), and 2 were not measurable by FeeD4Mi (e.g., "*students care too much about the results of peer assessment*" [Art]).

Participants proposed 21 reactions to support struggling learners under the abovementioned problems. FeeD4Mi confirmed 13 of them, such as improving peer assessment via "*rubrics on how to access*", offering good practices and clear explanations related with course actions, e.g., "*provide examples of good reflections*'' [Art] and applying gamification via leaderboards and badges. Participants reported 8 additional interventions, not supported by FeeD4Mi. Five (5) of them were related with the group formation and peer evaluations, such as "*some LA-based feedback about peers*", "*evaluation of peer members*" [Art]. Other proposals regarded "*breaking tasks in smaller steps*" and "*instructors can start threads in forums to boost the interaction among group members*" [Art].

Evaluative Study 4 [EV_4]

In [EV_4] we measured the catalogue completeness by: a) gathering the actual practices that the MOOC instructors followed to detect struggling learners and to provide support [Int] and b) asking them questions after concretizing their feedback strategies using e-FeeD4Mi [Int].

Before using the tool, all participants (N=6) mentioned they mainly encounter content-related and technical issues at their courses, being self-reported in discussion forums by the learners. Apart from content related and technical issues, other learners' problems were related to collaboration among peers and the request of additional activities to practice, due to the lack of their background knowledge. The above problems were all supported by FeeD4Mi. The only issue not covered by FeeD4Mi was the learners' issue with course payment to obtain their certificate. According to the evidence gathered, only one out of the 6 participants used to reflect on potential problems that might occur in the course to prepare feedback and 4 out of them tended to provide feedback on-demand without prior any reflection (see Table 6.2- a). One participant stated that during the course run-time they do not attend at all their learners (see Table 6.2- b).

Regarding the indicators they used to apply to detect struggling learners, participants noted 3 indicators covered by FeeD4Mi i.e., posts in forums, emails, and learners' interactions in chat activities. While all the participants mentioned that the platform provided them with dashboards to follow learner progress, 5 out of 6 did not check the dashboards at all either due to the

massive number of participants associated with their lack of time or because the visualised information is not meaningful enough (see Table 6.2- c, d, e). Only one participant tended to check learners' log data related to a chat peer-activity, but it was mainly for research purposes.

Finally, instructors mentioned 6 common feedback reactions, out of which 5 are covered by FeeD4Mi, i.e., hints, additional material, platform announcements, replies in forums by experts, automated feedback in multiple choice quizzes, and manual feedback in assignments. The aspect not fully covered regarded the provision of hints after each answer to a quiz test. FeeD4Mi catalogue foresees the provision of hints to learners, but e-FeeD4Mi supports hints in a general level and not per answer to a multiple-choice quiz, for instance. Our perceptions about high FeeD4Mi completeness were confirmed as well from participants positive reactions when using the tool. Table 6.2 (see excerpts *f, g, h*) presents the indicative excerpts of evidence.

Table 6.2. Excerpts of evidence associated with catalogue completeness in [EV_4].

Category	Labels		Excerpts of evidence
Problems	[Int]	a.	"*I do not reflect on anything in advance, but I have gathered and provide some notes for further support*"
	[Int]	b.	"*We provide automated feedback through the closed-ended exercises. There is only one open-ended assignment to reduce the need of interaction*"
Indicators	[Int]	c.	"*I have a dashboard, but they are so many learners that I cannot follow all of them and their progress there*"
	[Int]	d.	"*We have a dashboard, and we can see what learners are doing, but the data are aggregated. So, we do not check it, because they are not informative*"
	[Int]	e.	"*There is a dashboard but is not sufficient because the granularity level of the data is not the optimum. We have to ask the platform to provide us the rest of the data, but this is something we could not follow in real time and not with the granularity that we wanted*"
Completeness	[Rec]	f.	"*The categories were very clear, and I find them very complete*"
	[Rec]		
	[Rec]	g.	"*All the options I wanted they were there*"
		h.	"*In my use I used e-FeeD4Mi having all the possible learner problems in my mind, and I tried to translate it into the system. The catalogues had everything I needed*"

6.4.2. Results: FeeD4Mi Usefulness (Catalogues, Process, Recommendations)

To analyse the FeeD4Mi usefulness we studied the extent to which:

a. the FeeD4Mi *catalogues* helped the users to identify new problems, indicators, and feedback reactions

b. the FeeD4Mi ***process*** facilitated the design of feedback strategies by supporting the selection of problems, indicators, and feedback reactions,
c. the FeeD4Mi ***recommendations*** facilitated the users in the design of feedback strategies by providing concrete suggestions.

Catalogue Usefulness

[EV_1], [EV_2] and [EV_4] served for the evaluation of the catalogue usefulness. One way to examine the catalogue usefulness regarded the additional aspects that participants considered after being exposed to the FeeD4Mi catalogues. Table 6.3 presents the FeeD4Mi problems selected per evaluation study with the use of the problem catalogues. According to the findings, the most common problems reported in the three evaluative studies were the content understanding and previous background issues, the feedback related issues and the regulation-related issues.

Table 6.3. Learner Problems retrieved by FeeD4Mi during the three evaluation studies.

Learner Problems	**[EV_1]**	**[EV_2]**	**[EV_4]**
Regulation Issues	x	x	x
Feedback Issues (i.e., lack of useful or instant feedback)	x	x	x
Content Understanding	x	x	x
Previous Background Issues	x	x	x
Peer/ Collaboration Problems	x		x
Technical and Platform Issues	x		x
Community Building		x	x
Learning Design (i.e., Critical points that need to be fulfilled)			x
Community Building			x

Apart from the additional problems emerged with FeeD4Mi, participants expressed their doubts in examining some of the problems. For instance, in [EV_1] the MOOC instructor highlighted the difficulty and/or unawareness of how to deal with the following learners' problems:

- Participants referring to the problem of absent/non active members: "*It is an interesting problem at least to know why people left the course. But it is difficult to be addressed since there may be learners who have problems or others who are not interested*" [Rec].
- Participants referring to content-understanding issues. "*This is a typical discussion in the forum, they will go and say: He said that. what does he mean? It is an interesting problem but a hard one, since it is a production line, of course, as you understand, it's very difficult for me as instructor to go back and adapt some of the material*" [Rec].

Similarly, in [EV_2] the MOOC instructor decided to focus only on two learners' problems from all the learners' problems found as interesting to intervene, given her course design and platform technological constraints. Specifically, "*We don't have time to implement this, because we have to expand the dashboard in a way that needs a lot of time*" [Rec], "W*e cannot add an additional thread to forums and cover such problem, due to how the course is organised right now and that such a change implies the participation of many people involved in the design of the course*" [Rec].

In each of the studies, participants selected several indicators as potentially useful to identify the previously named problems. Table 6.4 presents the indicators that are associated with the four jointly reported problems in the three studies. Participants pointed out indicators mostly related with posts (or lack of answers) in discussion forums, visits to the content pages and activity scores under concrete thresholds.

Table 6.4. Indicators retrieved by FeeD4Mi during the three evaluation studies associated with learners' problems.

Problems Indicators	**[EV_1]**	**[EV_2]**	**[EV_4]**
Time spent in a course resource	**X** Content Understanding	**X** Lack of Self-Regulation & Content Understanding	
More attempts in a quiz	**X** Background Knowledge		**X** Background Knowledge
Submission delays	**X** Lack of self-regulation		**X** Lack of Self-Regulation & Content Understanding
Activity not submitted before a date			**X** Lack of self-regulation
Video features (pause/forward)	**X** Content Understanding		
Visits at a course resource more/less than…	**X** Content Understanding & Background Knowledge	**X** Lack of Self-Regulation & Background Knowledge	**X** Content Understanding
Activity Scores under a threshold	**X** Background Knowledge	**X** Lack of Self-Regulation & Background Knowledge	**X** Content Understanding & Background Knowledge
No visit of a course resource		**X** Lack of Self-	**X** Lack of Self-

		Regulation & Background Knowledge	Regulation
Post in forums without answer after a period of x days	**X** Feedback	**X** Feedback	**X** Feedback
Private message/platform notification to instructor	**X** Content Understanding		**X** Feedback & Lack of Self-Regulation & Content Understanding & Background Knowledge
Post with a concrete string	**X** Applicable for all problems	**X** Applicable for all problems	**X** Applicable for all problems

The evidence gathered indicates that the FeeD4Mi catalogue of indicators served for instructors to describe potential struggling behaviours. As expected, one indicator could serve for identifying various learners' problem. Characteristic is the case of '*private message or platform notification sent addressing the course instructor*' that in [EV_4] participants considered it as the most frequently applied indicator for all learners' problems. This finding shows that further attention is needed to the ways of managing self-reported learners' problems. Under the same prism, two instructors perceived positively the option of e-FeeD4Mi for 'self-monitoring indicators', with the creation of specific threads under which learners can report their problems. Concretely, "*I find this option interesting. During the course enactment it could help me manage better the problems that learners tend to self-report, because receiving a lot of private emails or messages is chaotic*" [Rec].

In [EV_1] and [EV_2], the participants expressed a difficulty on reflecting by themselves on LA-based indicators that connected with potential problems, i.e., "*I feel we are not very creative with our indicators*" [Rec]. However, after the use of the FeeD4Mi catalogue, participants eventually selected various indicators to build their feedback strategies, a fact that implies FeeD4Mi usefulness. During [EV_1] the instructors noted that, while some indicators may not be meaningful enough alone (e.g., time spent in the course), their combination with other indicators could reveal a potential problem, i.e., "*It might be a hint of course but it wouldn't necessarily mean that it wouldn't be the main one. Maybe if all these factors come together, I would say: "Okay, yeah, something happens*" [Rec]. Additionally, in [EV_2] instructors considered that the problem of 'lack of feedback' is not detectable, i.e., "*It is a problem that you know it exists a priori, I do not know how we can spot it*". Nevertheless, after

using the FeeD4Mi catalogue of indicators, participants found that the option of "*no replies at forum posts after a x-days period*" could alert them about such problem.

It seems interesting to highlight that in [EV_1], participants acknowledged that although they would like to pay attention to all indicators selected, they are limited, due to their personal high workload and the lack of support with the course, i.e., "*It's just now it's like two of us who deal with all this, because otherwise it will be very difficult. You know ideally sure you should have people keep an eye on all these indicators and move on. But at the moment we can't do it*" [Rec]. This finding was one of the reasons that led to the development of the FeeD4Mi design guidelines (#CON_2(d)), thus helping instructors in the design of feedback strategies with the help of a web tool.

Regarding the feedback reactions catalogue, we studied its usefulness in [EV_2] and [EV_4]. Table 6.5 presents the selected feedback reactions in these two studies. During [EV_4] we observed that instructors, despite the different options suggested, at first, they were inclined to the solutions that were more familiar with, i.e., to send personalised messages to learners to address the problems.

Table 6.5. Feedback reactions retrieved by FeeD4Mi during the two evaluation studies.

Feedback Reactions	**[EV_2]**	**[EV_4]**
Gamification	X Feedback	X Background Knowledge & Content Understanding
LD changes (e.g., special threads in discussion forums)	X Background Knowledge	X Background Knowledge
Mentoring-Connect with Peers	X Content Understanding	X Content Understanding
Provision of additional material	X Background Knowledge	X Background Knowledge & Content Understanding
Revisit course material	X Lack of Self-Regulation	X Lack of Self-Regulation
Norm referenced information	X Lack of Self-Regulation	
Information about the actual progress vs the estimated progress	X Lack of Self-Regulation	
Online Tutoring		X

		Content Understanding
Positive/Negative Exemplars		X Background Knowledge & Feedback
Hints/Cues		X Background Knowledge & Feedback
Predefined motivational message	**X** Lack of Self-Regulation & Background Knowledge	**X** Lack of Self-Regulation & Content Understanding

Participants' answers at questionnaires and researchers' observations complemented the evidence gathered. Concretely, in [EV_3] and [EV_4] participants highlighted the benefits of FeeD4Mi catalogues both for novice and experienced instructors (see Table 6.6- a, c, d, e, f), and its potential in learners' engagement (see Table 6.6- b). Additionally, in [EV_4] we observed that, 5 participants (out of 6) were interested in the FeeD4Mi catalogues and asked to design further feedback strategies with more problems and indicators than the maximum number we asked due to the limited time we had (see Table 6.6- g, h). Moreover, 2 participants reflecting on the catalogues of learner problems and feedback reactions created feedback strategies for positive reinforcement. Concretely, the instructors selected the problem of "Critical points/Milestones in LD) (see Table 5.1) and decided to send motivational messages to learners that showed a concrete video or passed a concrete activity (see Table 6.6- i).

Table 6.6. Excerpts related with the usefulness of the FeeD4Mi catalogues.

Study	Labels		Excerpts of evidence
[EV_3]	[Quest]	a.	"*I am new to the field, so everything is new for me. I have not thought in detail about these problems before"*
	[Quest]	b.	*"The use of a predefined feedback aspects opens up some new ways to increase the engagement of learners in the MOOCs."*
	[Quest]	c.	*"The different options regarding the rules allowed me to identify conditions I never thought about before*"
[EV_4]	[Int]	d.	"*I found the catalogues very understandable, and they provided me with many ideas."*
	[Int]	e.	*"The FeeD4Mi catalogues are interesting. Also, I think the more inexperienced you are the more useful, the more it helps. Or they are useful if someone wants to learn from the system, not only an inexperienced person but also an experienced one"*
	[Int]	f.	*"Sometimes I was surprised with some options, such as gamification, but yes I found interesting feedback options I had not thought as feedback before"*

	[Obs]	g.	*"When he found the 5 problems he asked if it is "enough" with the task, but later he saw the "community building" category and he asked us if he can add more problems because they are relevant. It seems that the catalogue made him reflect further"*
	[Obs]	h.	*"While configuring indicators, the participant says that she has noticed a new problem seeing the catalogues of indicators (i.e., Learning Path Issues). She asked if she could add an additional problem now. We replied positively, she configures it, and she returns to the previous page by herself"*
	[Rec]	i.	*Seeing now the feedback reactions, I would like to select from the previous problem list, the case of "when a learner passes this milestone" to give positive feedback to the learners who watched the video of Module 2 because it is crucial for the activities and the rest of the modules". Can I do it?*

The above positive findings agree with participants rates in [EV_3] at the five-Likert scale statement: "*FeeD4Mi suggested me feedback aspects (problems, indicators, reactions) that I did not consider before and which could be useful in my feedback design"*. In general, the catalogue suggestions were considered as useful for most participants (Med = 4 out of 5, IQR = 1.5). Additionally, we further investigated the extent to which participants' MOOC previous experience affects their perceptions. We calculated the Spearman's order-rank coefficient, selected due to the ordinal and non-numerical possible answers regarding the previous experience of participants (1-2 courses, 3-4 courses, 5+ courses). Results revealed a significant negative strong correlation (ρ=-0.896, p-value<0.001) between the catalogue usefulness and the experience as MOOC instructor. That is, the more experienced the participant was, the less useful the FeeD4Mi catalogue was.

Apart from the benefits, participants pointed out emerging difficulties accompanying the catalogue usefulness. More specifically, the reflection on the indicators seemed the most complex task that required further time during [EV_1] (see Table 6.7- a, b) and assistance in their interpretation in [EV_4] (see Table 6.7- c, d). This result points out the need to support more carefully the definition of indicators during the feedback design process.

Table 6.7. Excerpts of evidence related with catalogue limitations.

Study	Labels	Excerpts of evidence	
[EV_1]	[Rec]	a.	*"I feel we are not very creative with our indicators"*
	[Obs]	b.	*"The phase of indicators identification was more difficult for them [the participants] to proceed than the phase of the problems who run more smoothly"*
[EV_4]	[Int]	c.	*"Sometimes it was not clear who takes the actions in indicators, learners or instructors? It was a bit difficult sometimes to understand the available selection and interpret. Yet, I feel after 1-2 time I would be able to interpret them better."*
	[Int]	d.	*"The same at the beginning to understand the indicators it cost me a bit, but then I handled it well"*

Process Usefulness

We evaluated the process usefulness during the four evaluation studies. [EV_1] included a set of sequential tasks involving the first four FeeD4Mi dimensions (i.e., Learning Design, Learner Problem, Problem Indicators, Feedback Rules), that regarded a preliminary version of the FeeD4Mi process at the time. This study provided initial evidence about the added value and the challenges that might accompany such process, and the following three studies helped us to examine its application in different contexts and improve it.

The obtained data throughout the four DBR cycles showed that the FeeD4Mi process guided the participants during the design of the feedback strategies. Specifically, the following points emerged from the four evaluative studies related to the process usefulness:

- the reflection on aspects related to feedback in [EV_1] and [EV_3] (see Table 6.8- c, h)
- the concretization of the course design in [EV_2] and [EV_4] (see Table 6.8- d, k)
- the added value for novice instructors in [EV_1] and [EV_2] (see Table 6.8- b, e, f)
- the structure of the process in [EV_3] and [EV_4] (see Table 6.8- g, i, j)

Participants' positive perceptions about the FeeD4Mi process was further triangulated through researchers' observations (see Table 6.8- a) and through the high rates on the statements applied in [EV_3]: "*The process followed was helpful to design relevant feedback strategies*" (Med = 4 out of 5, IQR = 0.5) and "*The process followed was relevant/logical for the design of feedback interventions*" (Med = 4 out of 5, IQR = 0).

Table 6.8. Excerpts related with the FeeD4Mi process as examined during the evaluation studies.

Study	Labels		Excerpts of evidence
[EV_1]	[Obs]	a.	*"The participants are interested in the result of the artefact with the post-its, they wanted to keep notes of what we have said and asked for photos to have"*
	[Rec]	b.	*"Thank you, I was checking the post-its now and I realize that something that it was completely unknown to me, now it is more familiar. I had not realized how demanding is the work that needs to be done"*
	[Rec]	c.	*"I think it was useful to reflect on the things that we should maybe pay attention to. [..]I think that for future planning, it's also relevant".*
[EV_2]	[Quest]	d.	*"Now I have everything a little clearer about the course and learners' possible problems"*
	[Quest]	e.	*"We have gone very well reeling off my course and all these tasks helped us see things of my course that perhaps we did not know, as it happened with the Tool Developer"*
	[Int]	f.	*"The process did not just give me ideas, but it guided me on what to*

			look at and what to reflect on. Especially for me, the lack of knowledge on such aspects about feedback was very helpful"
[EV_3]	[Quest]	g.	*"It's a simple but well-designed process since every step depends on the previous one"*
	[Quest]	h.	*"It forces you to reflect on the feedback process"*
	[Quest]	i.	*"The process of identifying indicators for the problem at hand and then selecting proper reactions seems promising for providing more authentic feedback"*
[EV_4]	[Int]	j.	*"I definitely liked the flow, because it structured what you are doing and made a lot of sense to me how we got started with the annotations, later identifying problems etc. I found it super helpful."*
	[Int]	k.	*"To tell you the truth, what I found extremely useful in the process is the annotations part, and I would like to have this step for the entire design of the MOOC not only for feedback. I liked that the tool asks me and gives me options about my course LD, thus I would like to have it in general as a guide and be able to add the learning objectives and goals of the course, such as to include the Bloom taxonomy goals"*

Apart from the benefits, the long duration of the process and the order of the dimensions seemed to challenge some participants during the studies. In [EV_1] and [EV_2] the process duration seemed exhausting for the participants. In [EV_1] the preliminary version of the FeeD4Mi process lasted 1:30h and the participants wanted to quickly finish the session (see Table 6.9- a). Similarly, in [EV_2], where the process lasted 7:30h, since we applied the complete version of it in an authentic context, participants mentioned it is lengthy enough for applying it to every course (see Table 6.9- b). However, after the course enactment acknowledged the added value of the process despite its long duration (see Table 6.9- c). Furthermore, in [EV_4] one participant expressed her doubts about the more intuitive order of the process dimensions, doubting if the phase of reflecting on course LD (first process step) should go before or after the reflection on learner problems (second process step) (see Table 6.9- d).

Table 6.9. Excerpts of evidence related to the difficulties faced during the evaluation studies.

Study	Labels		Excerpts of evidence
[EV_1]	[Obs]	*a.*	*"The participants are in a hurry of finishing the task of indicators, they look tired"*
[EV_2]	[Int]	*b.*	*"The only thing I would like to change for a second round of using FeeD4Mi regards the timing on the co-design sessions. I do not know how it can be less because everything was useful, but it was very time-consuming"*
	[Quest]	c.	*"The process lasts a lot, but it cannot be done faster. It helped us reflect on problems, fit indicators, and concretize things"*
[EV_4]	[Rec]	*d.*	*"I find the process useful because you reflect on your own course. Yet, I doubt if it should go at the beginning or as a second step after the detection of the problems, so I don't know if this reflection is better done as a second step or at the beginning of everything"*

Recommendations Usefulness

The provision of recommendations emerged from the findings gathered in [EV_1] and [EV_3] as a means of supporting instructors in connecting LA indicators with learner problems and feedback reactions. Specifically, during [EV_1] we observed the difficulty of MOOC instructors to reflect on LA indicators (see Table 6.7- a, b). Similarly, in [EV_3], we observed participants difficulty to translate some problems to indicators so the course instructor can be alerted, i.e., "*We had some problems understanding how to express with indicators the problem of "not having enough reviews for the peer-review in a certain period of time". We managed to do it in the end (I think), but it was not that intuitive"* [Obs]. [EV_4] helped us to study the usefulness of the FeeD4Mi recommendations through researchers' observations and participants' reflections after the experience with e-FeeD4Mi.

[EV_4] participants preferred to follow often the recommendations provided. According to the evidence gathered, the 89.48% of the selected indicators and the 63.16% of the selected feedback reactions, per learner problem, arose from the FeeD4Mi recommendations. Participants' comments and researchers' observations support such finding. 5 out of 6 participants stated that the provision of recommendations facilitated them with ideas and suggestions to design feedback strategies more adequately (see Table 6.10- a, b). Likewise, the researcher observed the positive perception of a participant while consulting the recommendation list (see Table 6.10- c).

Apart from the positive experience, three participants proposed ideas for enhancing the recommendation sections and the operability of the tool (see Table 6.10- d, e, f). For instance, two participants proposed the use of predefined feedback strategies (i.e., pre-defined if/then rules with indicators and reactions under specific problems) that participants could pick directly and further fine-tune.

Table 6.10. Excerpts of evidence related to recommendations' usefulness in [EV_4].

Category	Labels		Excerpts of evidence
Positive Comments	[Int]	a.	*"In most cases I found the recommendations informative. I had the feeling I was able to select the best options due to recommendations. I had the best solutions"*
	[Int]	b.	*"If you have noticed, I found the recommendations ultra-useful, I have followed them because they gave me the best option. Having default options has been very useful"*
	[Obs]	c.	*"The instructor just commented out-loud that "The recommendations are very useful", and she says that she finds it difficult in general to think about the most adequate feedback reactions for each problem, so she follows the recommendations!"*

Future Suggestions	[Int]	d.	*"I would still like to be able to click directly on the recommendations and then fine-tuned them"*
	[Int]	e.	*"It would help me to have a set of predefined indicators, such as the performance indicators that can be applied to all courses. Then the user could directly fine-tune these predetermined sets of indicators"*
	[Rec]	f.	*"I think you should not go beyond 7 suggestions of recommendations, because they are the maximum that a user can have in mind"*

6.4.3. Results: Feedback Impact on Instructors and Learners

The application of the framework into an authentic MOOC context in [EV_2] permitted us to examine the impact of the feedback interventions to learners and instructors.

To begin with, during [EV_2] the instructor created automated and semi-automated feedback strategies for two possible learner problems, i.e., a) lack of previous background knowledge/ activities too difficult, and b) lack of self-regulation. These strategies were implemented in the LA tool edX-LIMS+, to automatize the detection of struggling learners and the delivery of the feedback. During the course enactment, 530 learners were identified as experiencing one of the two problems, with 436 identified as facing self-regulation problems and 94 difficulty difficulties, due to their background. From these learners, 31 interacted with the edX-LIMS+[16] message section and 25 of them (80.64%) confirmed experiencing the associated problem. Table 6.11 presents excerpts of evidence of learners reporting further about the challenges they face (see Table 6.11- a, b). Two learners also highlighted positively the interest they received from the instructor (see Table 6.11- c).

Table 6.11. Excerpts related with the impact of the feedback strategies.

Study	Labels		Excerpts of evidence
[EV_2]	[Quest]	a.	*"It is complicated for me to follow the course correctly, thus several times I missed some tasks"*
	[Quest]	b.	*"The content videos did not help me a lot"*
	[Quest]	c.	*"I am now organising my time to dedicate myself better to the course, thank you for your support!"*

The learners identified under one of the two selected problems received a predefined automated personalised feedback intervention. Additionally, the instructor provided further manual feedback, ranging from motivational

[16] EdX-LIMS+ is the LA tool that supported the implementation of the feedback strategies designed with FeeD4Mi in [EV_2].

emails to restarting some assignments, for the learners who were more dedicated and closer to finish the course. According to the instructor, thanks to the combination of these two practices (i.e., the automated personalised feedback and the manual intervention) "*most of these learners returned to the course actively [...]*" and "*the vast majority finished satisfactorily the course*" [Diary].

The above information permitted us to understand the impact of the feedback interventions to learners created thanks to FeeD4Mi. Moreover, the evidence gathered from the instructor's weekly diary [Diary], and the post-course interview [Int] revealed how the instructor perceived the created FeeD4Mi if-then rules that were visualised in the updated edX-LIMs+. The instructor self-reported that "*the information about the detected learners is very interesting*" [Diary] and "*every time I spend more time, but it is well spent because every time I review the progress of more learners and thus, I can know when to intervene more appropriately*" [Diary]. Such findings were triangulated with the instructor's and the tool developer's comments during a set of post-course interviews conducted with each of them. Table 6.12 provides excerpts of evidence confirming the instructor's positive attitude on the shaped feedback interventions and the support that FeeD4Mi offered. In summary, the instructor and the tool developer seemed satisfied with the selected feedback strategies and the flexibility they offered to instructor with the re-design of the LA dashboard (see Table 6.12-a, c). Additionally, she stated that she considered successful the decisions taken and she would repeat the same problems-indicators-reactions (see Table 6.12-b).

Table 6.12. Excerpts of evidence regarding the impact of FeeD4Mi framework to MOOC instructor.

Informants		Excerpts of evidence
Instructor	*a.*	*"The dashboard before was very basic, and now it has been enriched a lot with the information of the feedback decisions. Being able to see the activity of the detected learners based on the FeeD4Mi decisions and metrics selected helped me a lot to shape a more targeted intervention for them"*
Instructor	*b.*	*"We could not apply all the problems we wanted initially, but to be honest I think that the two problems we focused on were successful because I could address concrete learners, improve their learning experience, and keep them in the course. This is what I wanted to do. I would choose the same conditions again, if I would repeat the experience. "*
Tool Developer	c.	*"I believe that apart from helping the learners, the rule-based conditions helped the instructors even more. They helped her to realize what happened with her learners. The learners received more concrete info about their actions. The instructor could filter the learners and check whom to help, who is interested in receiving support"*

6.4.4. Results: Perceived Workload

Perceived workload refers to the extent to which MOOC instructors recognized the design and implementation of feedback strategies using FeeD4Mi as manageable in terms of workload and time spent. [EV_1], [EV_2] and [EV_4] permitted us to evaluate the perceived workload of the FeeD4Mi use that was mainly associated with the duration of the FeeD4Mi process.

Briefly, as stated in Subsection *Process Usefulness*, during [EV_1] and [EV_2] instructors reported the lengthy character of the FeeD4Mi process, especially, using paper-based materials. In [EV_1], due to the long duration of the process, the instructors were not focused enough on the last tasks of FeeD4Mi process and wanted to quickly finish the session (see Table 6.9- a, Subsection *Process Usefulness*). Similarly, in [EV_2] participants mentioned that they would like to avoid repeating the duration of the process as it is, since they perceived it as time consuming. Nevertheless, after the course enactment the participants acknowledged the process benefits despite its duration (see Table 6.9- c, Subsection *Process Usefulness*).

Building on the abovementioned limitations, we implemented the paper-based version of FeeD4Mi into a web tool to automatise the process and reduce its long duration to a more manageable one. Table 6.13 presents a synthesis of the time spent during each phase of the FeeD4Mi process as recorded in our three evaluation studies. Briefly, the evidence gathered shows that within approximately 50 minutes of using e-FeeD4Mi the instructors were able to design at least three feedback strategies including the selection of problems, indicators, and reactions. Comparing to the paper-based version of the framework, in [EV_1] and [EV_2] the instructors devoted more than 1:30 minimum for the design of the feedback strategies.

Table 6.13. Time spent during each FeeD4Mi phase of the process in the evaluation studies.

Studies	Annotations in Learning Design	Reflection on Learner Problems	Identification of Problem Indicators	Selection of Feedback Reactions
[EV_1]	≈30 minutes	≈20 minutes	≈40 minutes	-
[EV_2]	≈40 minutes	≈1:30 hour	≈3:30 hours	≈1:30 hour
[EV_4]	≈10 minutes	≈10 minutes	≈20 minutes	≈10 minutes

The self-reported comments of the instructor in [EV_2] confirmed that while the process was long, still she was satisfied with the framework's results (see Table 6.14- a). In [EV_4], on the other hand, participants noted their

satisfaction with the time spent with the tool for the first time, thinking that in the future its use would be even more smoothly (see Table 6.14- b, c). Additionally, we observed that in two cases, while the participants could finish their tasks earlier, they preferred to continue exploring the tool (see Table 6.14- d).

Table 6.14. Excerpts of evidence related with the perceived workload.

Study	Labels		Excerpts of evidence
[EV_2]	[Rec]	a.	*"The process lasts a lot, but it cannot be done faster. It helped us reflect on problems, fit indicators, and concretize things"*
[EV_4]	[Int]	b.	*"I think I have spent almost 40 minutes and it's the first time using the tool. I think I would devote such time during my course design"*
	[Int]	c.	*"I found that there is a learning curve the first time you use the tool, at least for me. So, I felt I spent more time in indicators, because cognitively I had to proceed them, but designing each following problem was easier than the previous one. I think if I use the tool two more times everything will be straight-forward and faster"*
	[Obs]	d.	*"It seems that the participant has already understood the tool better and even continues adding several reactions and several indicators for the same problem, although he could move to the next one to finish earlier! We informed him that he can finish his designs and the task, if he wants because everything is completed, and this is NOT the case… it seems that he is not tired and asks to use the tool more. He is enjoying exploring the different actions of the different resources"*

6.4.5. Results: Perceived Usability

Perceived usability examines the extent to which e-FeeD4Mi was perceived as easy to use by the participants in [EV_3] and [EV_4]. In particular, [EV_3] served for a formative evaluation of testing and enhancing the first version of e-FeeD4Mi. The obtained results served to improve the tool, which was evaluated in [EV_4]. During both studies, the participants' comments and scores in questionnaire items illuminated the experience with e-FeeD4Mi.

To measure usability in [EV_4] we employed the the validated instrument *System Usability Scale (SUS)*[17] (Brooke, 2013). To permit the interpretation and comparison of the results with other evaluation studies, normally the SUS scores are translated to percentile ranks and letter-grades. In our case, the average SUS score obtained in [EV_4] was 78,33 (with minimum rate 55 and maximum rate 92,5) and which, according to the scale defined by Bangor, Kortum, & Miller (2008) corresponds to a rate B+ and represents a good level of usability.

[17] SUS is a standardized questionnaire that requires a minimum of 5 participants and its final score is calculated according to the following equation: SUS = 2:5(20 + SUM (SUS01; SUS03; SUS05; SUS07; SUS09) — SUM (SUS02; SUS04; SUS06; SUS08; SUS10)).

To complement our findings, we gathered the participants' insights related to the usability of e-FeeD4Mi during the two studies. According to the findings, participants found e-FeeD4Mi helpful for the design of feedback interventions and for guiding the instructor practices (see Table 6.15- a, b, d, g). Additionally, participants stressed the importance on the automatisation it offers when designing and delivering feedback considering the MOOC platform (see Table 6.15- e, f). Finally, one participant highlighted positively the tool interface and its ease of use (see Table 6.15- c).

Table 6.15. Excerpts of evidence regarding the usability of e-FeeD4Mi to MOOC instructors

Study	Labels		Excerpts of evidence
[EV_3]	[Quest]	a.	*"This tool is effective in MOOC practice"*
	[Quest]	b.	*"It will be an efficient way to summarize my actions as a teacher"*
	[Quest]	c.	*"It is built intuitively, has nice interface and it is easy to use"*
[EV_4]	[Rec]	d.	*"I find interesting the whole idea of having a feedback design tool"*
	[Int]	e.	*"What I liked the most regards the connection of platform indicators with the tool (e.g., whether or not a students completed an assignment or a test)"*
	[Rec]	f.	*"I find very useful the automation of commonly used feedback"*
	[Int]	g.	"*I also liked the visualisation of the flow with boxes because they reminded me where I am at all times, what I have to do next and what I did before"*

Additionally, we used the Net Promoter Score (NPS) item (Reichheld, 2003) to complement our usability understanding and measure e-FeeD4Mi potential adoption into the participants' future learning contexts. NPS is often applied to measure the potential adoption of a system and is calculated as the percentage of Promoters (participants selecting 9 or 10 in the likelihood-to-recommend item) minus the percentage of Detractors (participants selecting 0 to 6). NPS was employed in [EV_3] and [EV_4] and it gathered different values that witnesses the enhancement of the tool achieved throughout the third and fourth DBR cycle. Specifically, the NPS obtained in [EV_3] evaluation was -18, that showed the potential of the tool (*1 Promoter, 7 Neutrals, 3 Detractors*), and the need for improvement before being adopted. This finding is consistent with the fact that in [EV_3] we applied the first version of e-FeeD4Mi, which was functional but in need of improvements, as indicated by the participants. In this regard, few participants proposed future changes, such as the provision of hints in concrete steps of the process (see Table 6.17- a, b, c). In [EV_4] we addressed the limitations raised in [EV_3]. Thus, the value of the same item in [EV_4] was higher (i.e., 67, with 4 Promoter and 2 Neutrals*)* indicating its perceived usability. According to Reichheld (2003), this high score indicates the potential of a tool for its adoption.

Participants' additional comments during [EV_4] complemented our findings regarding e-FeeD4Mi adoption. For instance, all participants (N=6)

stated they were interested in including the feedback strategies designed with e-FeeD4Mi in their actual courses (see Table 6.16- a, c, d). Additionally, one participant highlighted the possibility of offering targeted feedback to specific cohorts of learners (see Table 6.16- b). Such finding confirms the usefulness of the tool and the interest of the participants in adopting the results of the tool (i.e., feedback designs) into their teaching practice.

Table 6.16. Excerpts of evidence about the potential adoption of the feedback decisions in [EV_4].

Labels		Excerpts of evidence
[Rec]	a.	*"I think I would apply the problems. There are problems we normally try to treat manually and with that system we could automate them. It is really helpful"*
[Rec]	b.	*"I liked the option of sending reminders to specific cohort of learners, as I designed it now. In my course I sent messages but to all of the learners because I cannot track them in real time"*
[Int]	c.	*"I find the tool very useful and would apply all the problems we deal with. In fact, I would like to spend more time now with the tool and configure even more problems. If I had to do everything manually, I wouldn't have the capacity to do it and what the tool provides me is that I automate several interventions a priori, so that during the course time I can focus on things that can't be automated anyway"*
[Int]	d.	*"The learner problems I chose were not random and if possible, I would like to include them in my lesson"*

Attending to the tool limitations, both in [EV_3] and in [EV_4] participants proposed several aspects they could serve for future enhancements. In [EV_3], participants detected certain tool constrains, such as the lack of hints to accompany some expected user action in e-FeeD4Mi (see Table 6.17- a, b, c). Such limitations served for the enhancement of e-FeeD4Mi and the use of the refined tool version in [EV_4]. In [EV_4], the participants noted other issues that could serve for future improvements of e-FeeD4Mi. Specifically, half of the participants (n=3 out of 6) stressed the need of visualising somehow the effect of the design decisions, of numbering the conducted actions within each dimension and they provided ideas for optimizing the user interface (see Table 6.17- d, e, f).

Table 6.17. Excerpts of evidence related to the e-FeeD4Mi enhancements proposed in [EV_4].

Study	Labels		Excerpts of evidence
[EV_3]	[Quest]	a.	*"While the platform is very user friendly, the number of different attributes might be a bit overwhelming"*
	[Quest]	b.	*"I think there should be an adaptive connection between the module type, potential problems and proper solution"*
	[Quest]	c.	*"There was a lack of hints of how using the system"*
[EV_4]	[Int]	d.	*"I basically missed seeing the impact of what I am designing. To that end could serve either additional screenshots or a box with further information to understand what you are designing and how it is applied to the end user"*
	[Int]	e.	*"There are many options, too many clicks and drop-down menus.*

		Potentially a drag-and-drop solution could facilitate the users"
[Int]	f.	*"The flow of the dimensions seems good to me. However, within each screen/dimension more improvement is needed regarding the order of executing the related actions. Many times, you have to do something downwards and then come back upwards. Thus, I would try to either list the steps or homogenize the order of the steps from top to bottom, and left to right"*

6.5. Discussion

The findings presented in Section 6.4 served to evaluate FeeD4Mi and e-FeeD4Mi by collecting useful information for improving the usefulness and functionality of the framework and the tool. Additionally, we had the opportunity to evaluate the dissertation proposals in an authentic MOOC scenario ([EV_2]) and with an heterogenous set of MOOC instructors (e.g., MOOC experience, MOOCs discipline) ([EV_4]).

The first examined topic (see Section 6.4.1) concerned the degree of completeness of the FeeD4Mi catalogues regarding the learners' problems, indicators and feedback reactions. In general, we consider that the more complete the FeeD4Mi catalogues are, the more helpful they will be for instructors' reflection on further ideas for building feedback strategies. Previous literature highlighted the support on instructors' reflection as a crucial aspect of an LD tool (Arpetti, Baranauskas, & Leo, 2014; Prieto, Tchounikine, Asensio-Pérez, Sobreira, & Dimitriadis, 2014). In our case, the gathered data revealed that FeeD4Mi can express most of the feedback strategies desired by the different stakeholders, especially the indicators and feedback reactions. Similarly, all studies revealed new potential aspects for problems, indicators and feedback reactions being finally added to the catalogue in the next FeeD4Mi versions. Concretely, each study indicated further problems related to the course type (i.e., self-paced or instructor-led) and the course LD, that were added to enhance FeeD4Mi and were addressed to the next study. Additionally, the three first evaluations showed problems which are supported by FeeD4Mi but needed further refinement to be able to express instructors' designs. This is the case of the problem mentioned in [EV_1] regarding the lack of proper interaction among the peers. Although the FeeD4Mi catalogues included peer collaboration problems (such as absent group members or group assessment issues), the issue of establishing proper interaction among the peers was not explicitly considered. Likewise, the four studies provided further ideas about feedback reactions (e.g., "evaluation of peer evaluators") and indicators (e.g., "number of off-topic words in forum posts").

At the same time, participants mentioned several aspects that the current version of FeeD4Mi does not support. For example, in [EV_3] participants noted learners' problems due to learners' different expectations with the course design, e.g., a MOOC that includes many compulsory activities. Nevertheless, FeeD4Mi aim is not on proposing core changes on the course design, rather on helping instructors to design feedback given the concrete course particularities. As a result, FeeD4Mi includes feedback reactions for extending course deadlines, or augmenting quiz attempts, but it does not foresee changes on the way the activities are developed or on the learning goals and instructors' intentions. Additionally, in [EV_3] participants mentioned as indicators the use of "number of off-topic words in the forum", text-mining or "engagement indicators depending on the context". This evidence indicated the need of better clarifying the indicators that FeeD4Mi can support, since some of the participants' proposals require special tools and processes, such as text mining or detecting off-topic words. The current version of the framework is based on features extracted by learners' log data during the course enactment (e.g., videos watched, score in quizzes). Although these indicators served the thesis objectives, the incorporation of fine-grained indicators, such as the engagement indicators, is interesting and can be studied as future work. Similarly, in [EV_4] participants proposed the use of hints as feedback reaction per answer in each of the multiple-choice items. While hints are foreseen by FeeD4Mi as general feedback for tests and assignments, e-FeeD4Mi could not provide the use of hints per questionnaire item. Finally, in [EV_3] we observed that out of the 36 problems mentioned, 8 aspects were not problems rather general comments or indicator ideas, a fact that witnessed a difficulty or misconception on participants to reflect and conceptualise learner problems. Accordingly, further guidance or more concrete examples should be employed in FeeD4Mi to smooth such step.

The second research topic regarded the usefulness of the FeeD4Mi catalogues, process, and recommendations (see Section 6.4.2). The evidence gathered indicated that FeeD4Mi catalogues helped MOOC instructors to reflect and design feedback strategies. Specifically, in [EV_3], the strong negative correlation between participants' MOOC previous experience and their perceptions revealed that the less experienced the participants are, the more informative the catalogues were. In practice, we found that even in cases where instructors considered that some problems could not be detected, after the use of FeeD4Mi they re-considered indicators that could serve for the identification of such problems. For instance, in [EV_2] participants were interested in addressing the problem of lack of Instant Feedback to learners. While initially they claimed that such problem cannot be detected, after using the FeeD4Mi catalogue of indicators, participants selected 5 indicators that could alert them

about such problem (e.g., "*no replies at forum posts after a x-days period*"). Additionally, we observed that MOOC instructors considered the private messages they receive as the main indicator for learners' problems detection. This finding indicates that further proposals are needed to support self-reported actions on behalf of the learners in case they are struggling. In that sense, e-FeeD4Mi offered the possibility of creating specific thematic threads where the learners can report their problems, an action that was perceived as helpful by the instructors. However, we observed that that participants found it difficult to reflect on and interpret some of the proposed indicators. This result points out the need of studying more usable ways of presenting these catalogues. The inclusion of some examples and further hints could potentially support better the feedback design process. With respect to the FeeD4Mi process, participants' comments and the high rates obtained in questionnaires regarding FeeD4Mi structure and usefulness in [EV_3] revealed the positive perception about its relevance and effectiveness for both experienced and non-experienced users. Also, in [EV_3] and [EV_4], when participants were asked about the aspects, they liked the most in using FeeD4Mi, the FeeD4Mi process was among the most highlighted ones. Nevertheless, we recognise that throughout the several DBR cycles, the use of FeeD4Mi was proven time-consuming due to the long duration of its process, a fact we aimed to improve implementing the framework into e-FeeD4Mi and automatizing some of the steps.

Attending to the FeeD4Mi recommendations, the evidence gathered from a) participants' strategies while using the tool, b) their self-reported comments, and c) our observations shed light on the usefulness of the provided suggestions. In particular, the participants seemed to perceive as helpful the supplied recommendations, since they followed the FeeD4Mi ideas, both in indicators and in feedback reactions per learner problem. These positive findings are consistent with prior studies in LD and orchestration tools for instructors. According to Verbert et al. (2012), conceptual or technological tools which support recommendation techniques seem to be preferred by instructors, given the guidance and the time-affordability they offer. Nevertheless, further studies are needed to explore the FeeD4Mi recommendations' added value, based on participants' provided proposals for future enhancements, mainly related with the provision of predefined sets of indicators or the total number of aspects that should be given in order not to overwhelm the user.

The third examined topic (see Section 6.4.3) was the effect of the feedback interventions designed with FeeD4Mi. In [EV_2] applied the designed feedback decisions in an authentic MOOC, assessing their perceived impact. The course

instructor recognized that the framework benefited her by a) enhancing the LA tool edX-LIMS+ with feedback strategies, b) by being able to target different cohorts of learners, and c) by providing different types of automated and semi-automated support to learners. She noted that through the interventions planned via FeeD4Mi she was able to support many of her learners to complete the course. From the learner viewpoint, we saw that although only a small number of learners interacted with EdX-LIMS+, the majority of them (n=26 out of 31) confirmed they were experiencing the problem suggested by FeeD4Mi. This fact confirmed the success of the indicators configured by the instructor with FeeD4Mi. The instructor perceived positively such finding, highlighting the possibility to maintain interaction with their learners, thus avoiding potential dropouts. Likewise, Ajjawi & Boud (2018) and Pitt (2019) stressed out the importance of fostering a dialogue among students and instructors as a way to "*close the loop*" (Clow, 2012) in a feedback process. Nevertheless, in our evaluations we acknowledge a lack of learners' perspectives about the received feedback interventions in a systematic way, thus further work is foreseen in this direction. The case of [EV_2] provided us with initial ideas about learners' perceptions on the received feedback, which should be complemented with further studies.

The fourth research topic (see Section 6.4.4) concerns the perceived workload regarding the use of FeeD4Mi as examined during [EV_1], [EV_2] and [EV_4]. Concretely, during [EV_1]and [EV_2] participants found the FeeD4Mi process as time-consuming and complex. Probably such complexity was influenced by the fact that in [EV_1] the reflection on indicators regarded the last task of the co-design sessions and the participants were already tired. Similarly, in [EV_2] we deem that the long duration of the process makes it quite time demanding. Our observations showed that designing feedback is an evolving process that requires many cycles and modifications on the decisions taken depending on the capabilities of existing platforms as well as the different personal and course constraints (e.g., changes in the course design). Participants perceived the process as essential yet time-consuming. To overcome the time barrier, we reorganised the process followed in a more structured way (e.g., dividing the sessions in shorter slots to avoid overwhelming the participants), we created more supporting material (e.g., recommendations), and we integrated FeeD4Mi into a tool, e-FeeD4Mi, to identify problems, indicators, so that instructors can select from a pool of options adapted to their LD. Thus, [EV_4] permitted us examine again the perceived workload through the application of e-FeeD4Mi. According to the evidence gathered, within a period of 40 minutes and using the tool for a first time, participants were able to design feedback strategies according to their course LD. Participants' satisfaction was expressed stating the manageable

character of the process. Our findings are aligned with the study of Dagnino et al. (2018) who conducted a systematic literature review regarding the needs of teachers in adopting of LD tools. The results indicated time as among the most critical parameters for instructors affecting the application or avoidance of tools into their teaching practices.

Our last evaluated topic regarded the e-FeeD4Mi perceived usability (see Section 6.4.5) explored in [EV_3] and [EV_4]. Evaluating e-FeeD4Mi permitted the evaluation of the design guidelines (#CON_2(d)). In both studies the general perceptions were positive and regarded the support it offers to MOOC instructors to automate their decisions, its pleasant interface, and the potential in retrieving the MOOC platform indicators. However, in [EV_3] the negative Net Promoter Score (-18) and various comments in the final questionnaire pointed out several limitations associated with the lack of descriptions and hints in the tool that could ease its use. Also, the lack of flexibility, especially on the indicator selection page, was pointed out as a potential drawback that might affect to the Net Promoter Score. Building on such input, we informed the re-design of the e-FeeD4MI in the fourth DBR cycle and further evaluated it in [EV_4]. In our last evaluation study, participants highlighted the flexibility the tool offers for the design of feedback strategies and the support through its hints and guides. The evidence gathered showed a very good tool usability, given the high rate in SUS scale (i.e., 78,33) and a positive NPS value (i.e., 67). Such finding has been triangulated with the positive comments of participants who declared they would like to adopt the designed feedback strategies to their real courses. However, participants stated they lacked a clear order of the actions that need to be accomplished withing each dimension. Numbering the desired actions within each dimension could optimize the user interface. Altogether, the results show a good usability and potential to be adopted by third parties and offered ideas for further tool enrichment. Therefore, we can conclude that the design guidelines permitted the digital representation of FeeD4Mi and management of the feedback designs. Our encouraging findings are in accordance with the findings of Dagnino et al. (2018). Concretely, the examined papers seemed to place the ease of use as among the most desired and valued parameters of ICT and LD tools for instructors.

In summary, the evidence gathered from the five topics (i.e., Catalogue Completeness, Usefulness, Feedback Impact, Perceived Workload, and Perceived Usability) permitted to answer the general question that guided the evaluations: "*How can FeeD4Mi support instructors in the design and provision of personalised LA-informed feedback in MOOCs?".* The positive results obtained confirm that FeeD4Mi, through its catalogues, process and set of recommendations, enables instructors: (a) to clarify parts of their course

design, (b) to identify potential learners' problems according to the course LD, (c) to detect potential behaviours of learners based on their trace data, that can show learners having an expected problem, (d) to choose targeted interventions considering the feedback timing and the feedback focus, and (e) to make the connections among learner problems, indicators and feedback reactions. Additionally, the evidence gathered regarding e-FeeD4Mi usability, adoption, and workload indicate that the implementation of the framework into e-FeeD4Mi, thanks to the design guidelines, automated and made timely affordable the process of the design of LA-informed personalised feedback in MOOCs. At the same time, our evaluative work revealed certain limitations of our framework, such as the need of further guidance on interpreting the catalogue indicators. The limitations encountered during the four DBR cycles serve for future research and are presented in detail in Chapter 7.

6.6. Conclusions

In Chapter 5, we proposed the conceptual framework FeeD4Mi, its components (i.e., dimensions, catalogues, process, and recommendations) and a set of design guidelines. These contributions permitted the implementation of the framework into the web tool e-FeeD4Mi, as a means of supporting the reflection, design, and deployment of feedback strategies for MOOC contexts. This chapter presented the evaluation of such proposals through four studies that were carried out during the DBR cycles of this dissertation.

Concretely, the evaluative studies served both for a formative evaluation, i.e., FeeD4Mi refinement and consideration of the emerged requirements, and for a summative evaluation, i.e., assessment of the extent to which FeeD4Mi served to accomplish the thesis objectives. During each evaluation the following research topics were validated: a) catalogue completeness, b) usefulness, c) feedback impact, d) perceived workload and e) perceived e-FeeD4Mi usability in relation to FeeD4Mi.

The proposal of the framework and its associated components helped us to attain the OBJ_2 of the current dissertation (i.e., *to help instructors identify parameters that potentially describe struggling learners in MOOCs and shape tailored feedback interventions*). Additionally, the outcomes of the FeeD4Mi evaluation, which is presented in this chapter (e.g., the high rates of the catalogue completeness, the positive findings regarding the usefulness of the FeeD4Mi components, the perceived impact of the feedback strategies) led us to analyse in depth the implications of the use of the framework with MOOC instructors. To that aim, we followed an interpretative approach that enabled us to gain the contextual knowledge required to understand and interpret the results. Likewise, the enhancements made on the initially perceived time-

consuming process through the implementation of the framework into e-FeeD4Mi, and the high usability as perceived in [EV_4], led us to accomplish OBJ_3 (i.e., *to assist instructors in the consideration and design of feedback in a manageable manner*). The next chapter discusses the implications of the limitations met during the evaluative studies and presents several research lines for future work.

Chapter seven

CONCLUSIONS AND FUTURE WORK

Summary: This chapter draws the **overall conclusions** of the current dissertation summarising the main research goal (i.e., how to support instructors in the design and provision of personalised LA-informed feedback in MOOCs), the proposed objectives and contribution. The results obtained from the four evaluative studies provided enough evidence regarding the **attainment of the research objectives**. Furthermore, the outcomes pointed out **further research lines** to be potentially explored in the future. For example, lines of future work regard the application of FeeD4Mi in Higher Education and the extension of the FeeD4Mi catalogues with high-level indicators. The contents of this dissertation are published (or are currently under review) in 3 JCR-indexed peer reviewed journals and in six international conferences. This fact indicates the relevance, originality, and significance of the contributions and evaluations presented in this dissertation.

7.1. Conclusions

According to the literature, the three mainstreamed lines of research about feedback in online learning contexts are: a) the use of LA for informing and scaling feedback interventions (Lim et al., 2021; Tsai & Gasevic, 2017), b) the consideration of the LD (i.e., the instructional design decisions about the course) for informing more pedagogical and contextualised LA-based decisions (Mangaroska & Giannakos, 2019; Shibani et al., 2019), c) the exploration of Human-Centred LA (HCLA) approaches that actively involve the stakeholders, among others, in the co-design and/or co-creation of LA tools (Dimitriadis et al., 2021; Shum et al., 2019). The union of these tendencies regards the research context of this dissertation: the provision of LA-informed feedback in MOOC settings considering the course particularities and involving the course instructors as active agents in the design of feedback interventions. Nevertheless, when put in practice, the above proposal indicates certain challenges, such as instructors' lack of guidance in connecting LA and LD, and

the high workload needed for designing personalised feedback interventions in massive contexts. As a result, this dissertation focuses on how to support MOOC instructors in planning scalable interventions, personalised to learners' behaviours, that are contextualised within the course learning design and feedback theories (Figure 1.1).

At the beginning of this dissertation, we explored the current body of research regarding the identification of learners that might need feedback, and the identification of MOOC instructors' needs in designing feedback interventions in MOOCs. Additionally, we conducted three exploratory studies (reported in Chapter 3) having as informants both MOOC learners' and MOOC instructors. Our exploratory work permitted us to collect recurrent learner problems in MOOCs. Moreover, the findings obtained suggested the need of conceptual and technological LA tools for MOOC instructors to support them in the identification of struggling learners and in the provision of personalised feedback interventions. Accordingly, exploring the LA tools in MOOCs related to the design and provision of instructor-led feedback seemed critical. Thus, we formulated the first objective of this dissertation (#OBJ_1): *to understand the current state of instructor-led LA-informed feedback in MOOCs.*

While there are reviews discussing the potential of LA for feedback in education in general (Avella et al., 2016; Cavalcanti et al., 2021; Chiappe & Rodríguez, 2017; Lim et al., 2021; Mangaroska & Giannakos, 2019; Schwendimann et al., 2017; Sharma et al., 2020; Sunar et al., 2016), there is a lack of systematic literature reviews discussing the use of LA tools for automatic or semi-automatic instructor-led feedback in MOOCs. Consecutively, we considered essential to understand the impact of LA-informed feedback in MOOCs to later be able to support better the feedback providers (i.e., instructors) in shaping suitable interventions. This objective led to the first contribution of the current thesis, i.e., ***a systematic literature review on the state-of-the-art of LA-informed feedback in MOOCs.***

The systematic literature review showed that the field is still evolving, given the increasing interest on the topic, the variety of proposed solutions and the growing number of journal papers. Additionally, the review also helped to identify the most frequent feedback purposes (e.g., increase learners' engagement and motivation, boost self-regulation skills), the commonly applied learners' log data captured by the LA tools (e.g., activity scores, video events), the ways applied to provide feedback (e.g., through visualisations, recommender systems). Nevertheless, the results revealed lack of LA tools grounded on pedagogical theories and instructional design, which might impact the benefits of instructor-led LA-informed feedback interventions. Additionally, the examined LA tools in our systematic literature review did not

consider the need for further guidance on awareness and use of the data-driven information to design feedback interventions. Previous literature pointed out that MOOC instructors often need additional support in interpreting and using the LA information (Estrada-Molina & Fuentes-Cancell, 2022; Fernández-Nieto et al., 2022; Mangaroska & Giannakos, 2019). These conclusions led to the second objective of this dissertation (OBJ_2): *to help instructors to shape personalised and contextualised feedback interventions in MOOCs.*

This objective consists of supporting instructors in a) detecting cohorts of learners who might face problems during the course enactment and b) considering several feedback-related aspects (e.g., feedback timing and feedback focus) to shape suitable interventions to address learners' problems. To accomplish these goals, we proposed the second thesis contribution: ***FeeD4Mi, a conceptual framework to guide instructors in the design of LA-informed feedback interventions in MOOCs.*** FeeD4Mi consists of the following components:

- ***a set of 5 dimensions*** aimed at framing the steps needed for the design of successful feedback strategies. The five dimensions, namely *Learning Design, Learners' Problems, Problem Indicators, Feedback Rules, Feedback Reactions*, compose the FeeD4Mi process. These dimensions emerged from the literature review and the conducted exploratory studies.
- ***a process*** aimed at guiding instructors in the design and implementation of feedback strategies. The process is foreseen to include a) the participatory design on behalf of the instructors, b) the way to identify the different learner cohorts based on their trace data during the course and c) the corresponding feedback intervention (#CON_2(a)).
- ***a set of catalogues*** with information about potential learners' problems that are recurrent in MOOC contexts (gathered from the literature and our exploratory and evaluative studies), indicators to identify learners under the different problems (collected mainly from [Exp_2] study and the systematic literature review) and different types of feedback reactions (organised according to the taxonomy of Hattie & Timperley (2007) and informed as well by our evaluative studies and other models, such as the ones of Mason & Bruning (2001), Molloy & Boud (2014), Shute (2008), Wood & Wood (1996)) to support MOOC instructors' reflection on feedback-related parameters (#CON_2(b)).

- **a set of recommendations** of indicators and feedback reactions, that support instructors' reflection during the design and implementation of feedback strategies (#CON_2(c)).

During the four evaluative studies (see Section 6.2), we evaluated the FeeD4Mi (and its associated components) completeness, usefulness for MOOC instructors, and feedback impact both on learners and instructors. The results were positive indicating the added value of the catalogues in supporting instructors' ideas and providing further suggestions to design feedback strategies. Additionally, the FeeD4Mi process guided the participants on what aspects to consider during each FeeD4Mi dimension. However, a limitation emerged regarded instructors' difficulty in reflecting on LA indicators. The evaluation on FeeD4Mi recommendations happened in the fourth evaluative study with 6 MOOC instructors (see Section 6.2.4). The results suggested their usefulness, with instructors to follow them both in choosing indicators and in selecting feedback reactions according to the previously selected learner problems.

Another limitation noticed in the two first evaluations considered the time-demanding duration of the FeeD4Mi process and the lack of possibility to apply the feedback strategies directly at the course. Indeed, initially, we asked the participants either to manually design the feedback strategies making use of FeeD4Mi in a paper-based version (see Section 6.2.1), or to implement their feedback designs into an existing LA tool having to re-adapt it (see Section 6.2.2). Instructors perceived both approaches time-consuming and tiring, thus leading us to specify the need for the third dissertation objective: (OBJ_3) T*o make manageable the design (and implementation) of feedback for MOOC instructors*. To accomplish the third objective, we suggested the fourth FeeD4Mi component:

- **a set of design guidelines** to incorporate the proposed conceptual framework into tools to make the process more manageable for MOOC instructors and to support computer-interpretable feedback designs. (#CON_2(d)). The guidelines aim at assuring the smooth incorporation of the FeeD4Mi catalogues, the FeeD4Mi process and the FeeD4Mi recommendations as conceived in the paper-based version of the framework into a digital version.

Following the design guidelines, we incorporated FeeD4Mi into the web tool e-FeeD4Mi. e-FeeD4Mi permitted the evaluation of the design guidelines during our two last evaluative studies (see Sections 6.2.3 and 6.2.4). Concretely, we examined the tool usability, the workload, and the tool adoption, together with the FeeD4Mi usefulness and catalogue completeness.

The perceptions about the tool interfaces, the usability, the functionality and the framework usefulness and completeness were positive. Participants highlighted the flexibility that the tool offered to MOOC instructors, the possibility to automatise feedback strategies and the connection with the platform indicators. In conclusion, the evaluation outcomes showed that the design guidelines permitted the digital representation of FeeD4Mi and management of the feedback designs. It is worth mentioning, that apart from delivering feedback to struggling learners as initially intended, FeeD4Mi via e-FeeD4Mi also supported the design and delivery of positive feedback interventions reinforcing learners who achieve concrete milestones during the course run-time.

In summary, this dissertation tackled the issue of supporting instructors in the design (and provision) of LA-informed personalised feedback in massive contexts following the iterative nature of the Design-Based Research (DBR) methodological approach. The aspect of "*LA-informed*" feedback permits the scalability of the feedback intervention, and the active involvement of the instructors as main feedback providers permits the feedback contextualisation under the course peculiarities. To address the dissertation goal, we provided a systematic examination of the instructor-led LA-informed feedback in MOOCs (#CON_1), that itself raised the need of the FeeD4Mi design and development, i.e., our proposal to support instructors, with its components (#CON_2).

7.2. Limitations

The proposal of our contributions and the development of the four evaluative studies was accompanied by several limitations. The challenges are discussed below and can inform future research studies on LA-feedback in MOOC contexts.

× **Practical constraints related to the low availability of MOOCs**: One of the main limitations of the current thesis regards the lack of iterative testing and application of the FeeD4Mi framework in authentic contexts in the phase of course enactment. Considering that the interest of the current dissertation is framed in MOOCs, the low availability, and the lack of access to suitable courses hindered the analysis and evaluation of our proposals into the life cycle of real MOOCs. During the second cycle of DBR we had the opportunity to apply our framework in a real ongoing course. This evaluation offered us empirical and rich insights about the use of the framework contextualised in an authentic scenario. At the same time, according to the obtained findings, we consider that there is still work to be done in this regard. Conducting further evaluative studies in authentic contexts would have allowed to

understand better the FeeD4Mi weaknesses and strengths in practice and enhance them.

× **Data collection and sample size constrains:** Another encountered challenge regarded the data availability of the different MOOC platforms. Indeed, during our studies we faced problems in accessing learners' data, due to platform limitations when it comes to data disposal and the GDPR privacy restrictions in different countries. This is a reason why a preliminary evaluation on the feedback impact to MOOC learners was carried out only in [EV_2].

× **Methodological limitations:** Another limitation of the current dissertation is associated with the evaluation of the framework that cannot support generalisable results. In fact, given our interpretative research approach, we aimed at achieving transferability instead of generalisation. We acknowledge that by having more informants we could have uncovered the different needs for the proposed LA-informed feedback solutions. Nevertheless, the thick description of the study context, the members' checking, the triangulation and complementation of multiple data sources and of several informants during different evaluation happenings provided a deep understanding of the topic and guaranteed the credibility and transferability of our research (Guba, 1981; Twining et al., 2017). Following DBR, we intended to support a 'naturalistic' generalisation, (Stake, 1978, p. 6): to provide extensive information of the under-study situations and to permit reflections on the extent to which our findings can inform other cases in relation to the active involvement of the human actor at the design of the feedback process.

7.3. Future Lines of Work

Having the above limitations in mind, together with the results of our evaluative studies and the application of our contributions, further research directions emerge. We discuss the potential research lines under the two following classifications: (a) evolutionary extensions of the research work building on the dissertation outcomes, and (b) potential application of the dissertation proposals into emerging TEL research areas.

7.3.1. Potential Research Expansions

This subsection introduces future lines of work related to the research goals of the dissertation, given the evidence gathered during the conducted evaluative studies and general research work.

- **Study the impact of feedback strategies on learners**

As described earlier, one of the research interests of the current dissertation regarded the exploration of the effect of the feedback strategies designed with FeeD4Mi on MOOC learners. However, when carrying out the evaluation studies, the data collection constrains combined with the fixed timeline of the doctoral thesis held back such focus. As future work is foreseen the FeeD4Mi application in real MOOC cases and the collection of learners' impressions regarding the provided feedback interventions (e.g., if they are satisfied from the provided feedback, how they use the provided feedback) in a systematic way. Gaining further insights on both learners and instructors' impressions about the feedback designed with Feed4Mi would help to refine the connections between the elements in the Feed4Mi catalogues. That is, the extent to which the indicators proposed and used by MOOC instructors really identify learners with the selected problems.

- **Update the catalogue of feedback reactions in association to FeeD4Mi recommendations**

As observed in [EV_4], while FeeD4Mi offered plenty of options of feedback reactions, the more selected interventions were to send personalised messages, a strategy usually applied by the instructors. This finding could happen, due to possible FeeD4Mi weakness in reporting effectively the feedback reactions. While increasing the feedback literacy was not planned as an objective of the current dissertation, in the future we aim to study how to better present the feedback reactions to facilitate instructors make the best out of them according to the feedback theory. A potential research work regards the restructuring of the FeeD4Mi reaction catalogues following the Contingent Tutoring Theory from Wood & Wood (1999). Wood & Wood suggested several principles for achieving contingency in feedback and proposed different levels of interventions (e.g., hints, informative tutoring) based on students' regulation during the learning process. FeeD4Mi catalogues include a variety of feedback reactions, yet we would like to study whether their reorganisation and presentation under different levels of contingency would a) facilitate the instructors to select better their feedback reactions and b) eventually affect the learners regarding their course engagement.

- **Employment of High-Level Indicators in FeeD4Mi**

Participants in [EV_3] proposed the use of indicators, e.g., 'engagement indicators' which cannot be supported by the current version of the framework. Therefore, inserting high-level indicators could be a possible future research line to be considered. The current version of the framework is based on features extracted by learners' log data during the course enactment (e.g., videos watched, score in quizzes). While such indicators served the purposes of the research objectives, there are further aspects that may affect the learning processes, such as motivation, cognitive-affective states (e.g., stress, emotions), self-regulation and social engagement (i.e., socially shared regulation) etc. The incorporation of such high-level indicators captured using different data sources, and even in different modalities, may enhance the FeeD4Mi support to MOOC instructors. For instance, instructors could configure a feedback reaction for those learners that seem not to be very engaged within Module 2 as compared with the previous Module. Also, an instructor might want to configure a feedback reaction for those groups that are not socially regulating in the performance of a collaborative task.

Under the same prism, previous studies shed light into different learners' goals, competences, learning patterns and objectives, exploring how they affect learners' regulation or learning during the course runtime (Fincham, Gašević, Jovanović, & Pardo, 2019; Jovanović, Gašević, Dawson, Pardo, & Mirriahi, 2017; Prins et al., 2008). A possible research line could regard the exploration of the various learners' tactics during the MOOC enactment to provide personalised feedback to different learner cohorts.

- **Application of e-FeeD4Mi in real settings (MOOCs and/or HE)**

Given the fixed timeline of the dissertation and the difficulty of finding suitable MOOC cases on time, we did not achieve to study the use of e-FeeD4Mi into a real MOOC. During our four DBR cycles we had the opportunity to apply the paper-based version of the framework (see Section 6.2.2) into an ongoing course. The outcomes of the study pointed out the FeeD4Mi benefits and helped us to detect weaknesses of the FeeD4Mi process that we would have the opportunity to identify without this application. Thus, an application of e-FeeD4Mi into an authentic context is foreseen to understand how the digital version of the framework works within instructors' teaching practices.

Additionally, during [EV_4], two instructors expressed the desire to use FeeD4Mi not only at their MOOCs, but also at their university courses. Building on such ideas, we aim to explore the usefulness of FeeD4Mi in Higher Education (HE) and hybrid learning contexts. Such shift would require an a priori understanding of the new contexts and their limitations to eventually consider differences in terms of LD expressivity in the context of instructors' use to update the framework accordingly. Concretely, the first two dimensions

of FeeD4Mi regard the course LD and the learners' problems, which at the moment are related directly with the massive and open nature of MOOCs. In this case, it would be necessary to see the applicability of these problems in other contexts, the usefulness of the recommendations made (which come from the MOOC literature and our studies) and the implementation of e-FeeD4Mi on other platforms of HE.

- **Exploration of more opportunities for on-demand feedback**

FeeD4Mi provides opportunities for delivering personalised and timely feedback mainly by positioning instructors in the role of detecting learner behaviours that require further assistance. While we include the option for learners to self-report their problems, more elaboration is needed on that topic, given the high preference of instructors in [EV_4] in such indicator. Literature about feedback in online learning settings suggested the reinforcement of opportunities for on-demand help, where learners have the possibility to declare their need for receiving support (Patikorn & Heffernan, 2020; Wood & Wood, 1999). A future research line could regard to explore the adaptation of FeeD4Mi to better encourage such possibilities.

7.3.2. Prospective Application of Proposals in TEL

This subsection proposes emergent research lines in TEL based on the lessons learned from the conducted research work.

- **Research regarding feedback in MOOCs**

The findings suggested the need for a rigorous empirical evaluation of the overall impact of LA-based feedback in MOOCs. That is, we detected a gap about the assessment of instructor-led LA-informed feedback interventions that hinders a deeper understanding of the impact of LA-based feedback and its usefulness both to learners and to instructors. As a future research work, we foresee to study the use of FeeD4Mi via e-FeeD4Mi to gain further insights into the impact of feedback on learning, on instructors' teaching practices and on instructors' presence in feedback processes.

- **Promotion of the feedback literacy in the post-COVID era**

The COVID-19 pandemic shed light into ongoing vulnerabilities in the educational landscape, such as the lack of preparation to shift from face-to face to online and digital settings. Building on the above context, the International Commission on the Futures of Education delivered several guidelines for public action in the Agenda of 2020 Sustainable Development to overcome some educational discrepancies emerged during COVID-19 (International Commission on the Futures of Education, 2020). Among such guidelines there is the adoption of digital spaces and the need of fostering the development of

digital literacy of both learners and university teachers. Likewise, University of Valladolid, like many other universities, following the current strategic actions in research, strives for the enhancement of online teaching and the support of in digital skills training [18].

Within the abovementioned context, the research work conducted in this dissertation may serve for promoting the feedback literacy within the online settings. Specifically, the above orientations of the educational community affect the teachers, who within their classrooms would requires an a priori assistance in monitoring and supporting their students maintaining the same time vivid teacher-to-student interaction. In Chapter 2, we discussed the differences of the feedback practices between conventional and online settings, with the last ones to require a consideration of learners' individual progress through LA, the detection of critical behaviours according to course milestones and the provision of different level, kind and timing of support based on the evidence gathered (Mason & Bruning, 2001; van de Pol et al., 2010; Wood et al., 1995). Additionally, the proposed conceptual and technological tools that a) pose the human agent at the centre of decision-making and b) are informed by the learning context and could serve for a reflection on the teachers' needs for monitoring tools and on points that may require attention (e.g., lack of digital competences, difficulties in interpreting LA).

7.4. Publications and Research Projects

This section presents the research publications (already published or submitted for review) and the associated research projects related to the work described throughout this dissertation. The publications presented below underline the relevance of this research.

7.4.1. Publications

Publications in JCR-indexed journals

- [JCR Q1] **Topali, P.**, Chounta, I.A., Martínez-Monés, A., Villagrá-Sobrino, SL. (2022). Delving into feedback interventions informed by Learning Analytics in MOOCs. *Under Review*

- [JCR Q1] **Topali, P.,** Cobos, R., Agirre-Uribarren, U., Martínez-Monés, A., & Villagrá-Sobrino, S. L. (2022). Co-Design and Evaluation of Instructor-led LA-informed Feedback in MOOCs. *Under Review*

[18] https://digital.uva.es/ Last access in July 2022.

- [JCR Q3] **Topali, P.**, Ortega-Arranz, A., Martínez-Monés, A., & Villagrá-Sobrino, S. L. (2021). "Houston, we have a problem": Revealing MOOC practitioners' experiences regarding feedback provision to learners facing difficulties. *Computer Applications in Engineering Education*, 29(4), 769–785. https://doi.org/10.1002/cae.22360

Publications in international conference proceedings

- **Topali P.**, Hilgemann R., Chounta I.A (2022). "Click it, when you need it": On-demand feedback for online settings. In: *Proceedings of the 30th International Conference on Computers in Education Asia-Pacific Society for Computers in Education*. ISBN: 978-626-968-900-2

- Ortega-Arranz, A., **Topali, P.**, Asensio-Pérez, J. I., Villagrá-Sobrino, S.L., Martínez-Monés, A., & Dimitriadis, Y. (2022). e-FeeD4Mi: Automating Tailored LA-informed Feedback in Virtual Learning Environments. In: *Proceedings of the 18th Conference on Technology-Enhanced Learning* Springer, Cham. pp. 477-484. https://doi.org/10.1007/978-3-031-16290-9_39

- **Topali, P.**, Ortega-Arranz, A., Martínez-Monés A., Villagrá-Sobrino, S.L., Asensio-Pérez J.I., Dimitriadis Y. (2021). Identifying Learner Problems Framed within MOOC Learning Designs. In: *Proceedings of 29th International Conference on Computers in Education Conference,* ICCE 2021. pp. 297–302. ISBN 978-986-97214-7-9

- **Topali, P.**, Ortega-Arranz, A., Chounta, I. A., Asensio-Pérez, J. I., Martínez-Monés, A., & Villagrá-Sobrino, S. l. (2022). Supporting instructors in the design of actionable feedback for MOOCs. In: *Proceedings of IEEE Global Engineering Education Conference*, *EDUCON2022.* pp. 1881-1888. https://doi.org/10.1109/EDUCON52537.2022.9766546

- **Topali, P.**, Ortega-Arranz, A., Dimitriadis, Y., Martínez-Monés, A., Villagrá-Sobrino, S. L., & Asensio-Pérez, J. I. (2019). "Error 404- Struggling Learners Not Found" Exploring the Behaviour of MOOC Learners. In: *Proceedings of the 15th Conference on Technology-Enhanced Learning.* Springer, Cham. pp. 636–639. https://doi.org/10.1007/978-3-030-29736-7_56

- **Topali, P.**, Ortega-Arranz, A., Er, E., Martínez-Monés, A., Villagrá-Sobrino, S. L., & Dimitriadis, Y. (2019). Exploring the Problems Experienced by

Learners in a MOOC Implementing Active Learning Pedagogies. In: *Proceedings of the 2019 EMOOCs Conference*. Springer, Cham. pp. 81–90. https://doi.org/10.1007/978-3-030-19875-6

7.4.2. Research Projects

This subsection presents the research projects close-related to the context of this dissertation, and to which the work performed in the dissertation supported their fulfilment:

- **H2O Learn**-UVa: *Aprendizaje Híbrido y Orientado al Ser Humano: Analítica de Aprendizaje Confiable y Centrada en la Persona para la Educación Híbrida.*
  Date: 2021-2024. Funding entity: Ministry of Science and Innovation, Government of Spain (PID2020-112584RB-C32). Principal Investigator: Yannis Dimitriadis and Alejandra Martínez-Monés. Fund: 178.354€

- **Colaps:** *Combining Machine-learning and Learning Analytics to provide personalised scaffolding for computer-supported learning activities.*
  Date: 2019-2021. Funding Entity: Estonian Research Agency Foundation, (PUT grant PSG286). Principal Investigator: Angeliki-Eirini Chounta. Fund: 167.375€

- **ColMOOC:** *Integrating Conversational Agents and Learning Analytics in MOOCs*.
  Date: 2018-2020. Funding entity: Erasmus+ Programme KA2 "Action 2 Strategic Partnerships", European Commission (588438-EPP-1-2017-1-EL-EPPKA2-KA). Principal Investigator: Yannis Dimitriadis. Fund: 108.120€

- **SmartLET-**UVa**:** *Analítica del aprendizaje para mejorar el diseño y la orquestación en entornos inteligentes de aprendizaje escalables y ubicuos, enriquecidos con internet de las cosas.*
  Date: 2018-2020. Funding entity: Spanish Ministry of Science and Innovation (TIN2017-85179-C3-2-R). Principal Investigator: Yannis Dimitriadis and Miguel L. Bote-Lorenzo. Fund: 136.851€

Moreover, the knowledge acquired while conducting the dissertation favoured the contribution on the following projects:

- **Fertile:** *Artful Educational Robotics to promote Computational Thinking in a Blended Learning context.*

Date: 2022-2025. Funding entity: Erasmus+ Programme KA2, “Action 2 Strategic Partnerships”, European Commission (2021-1-EL01-KA220-HED-000023361). Principal Investigator: Yannis Dimitriadis. Fund: 67.153€

- **CASSSUALearn**: *Uso de la Web de Datos para Apoyar el Aprendizaje Contextualisado en Entornos Inteligentes de Aprendizaje.*
  Date: 2019-2021. Funding entity: Regional Government of Castilla y Leon (Spain) & FEDER (VA257P18). Principal Investigator: Miguel L. Bote-Lorenzo. Fund: 119.859€

Appendix A

APPENDIX A: ΕΚΤΕΝΗΣ ΠΕΡΙΛΗΨΗ ΔΙΑΤΡΙΒΗΣ

Το πρώτο παράρτημα συνοψίζει το περιεχόμενο της διατριβής που παρουσιάστηκε αναλυτικά στα προηγούμενα κεφάλαια. Η συγκεκριμένη διατριβή εστιάζει στην υποστήριξη των καθηγητών για παροχή εξατομικευμένης ανατροφοδότησης στα Μαζικά Ανοικτά Διαδικτυακά Μαθήματα» (MOOC από τα αρχικά τους στα αγγλικά) Ακολουθώντας τη μεθοδολογική προσέγγιση «*Έρευνας Βασισμένης σε Σχεδιασμό*», η διατριβή παρέχει δυο προτάσεις αναφορικά με την εξατομικευμένη ανατροφοδότηση στα MOOC βάσει των ψηφιακών δεδομένων των μαθητών (δηλαδή, βάσει των Learning Analytics). Συγκεκριμένα, η διατριβή στοχεύει να παραθέσει **μια συστηματική βιβλιογραφική ανασκόπηση** σχετικά με τα εργαλεία και τις μεθόδους των Learning Analytics που χρησιμοποιούνται στα MOOC για την παροχή ανατροφοδότησης, αποκαλύπτοντας τις προκλήσεις και τους περιορισμούς που σχετίζονται με το θέμα. Δεύτερον, στοχεύει να παρέχει στους καθηγητές **ένα εννοιολογικό πλαίσιο** για την καθοδήγησή τους στον σχεδιασμό εξατομικευμένης ανατροφοδότησης. Οι ενότητες που ακολουθούν περιγράφουν **το γενικό ερευνητικό πλαίσιο της διατριβής**, **τα ερευνητικά ερωτήματα, τους στόχους και τη μεθοδολογία** που ακολουθήθηκε για την επίτευξη αυτών των στόχων. Επιπλέον, παρουσιάζει **τις δυο προτάσεις της διατριβής** και **τις μελέτες** που εκπονήθηκαν για την βελτίωση, επέκταση και αξιολόγηση του εννοιολογικού πλαισίου. Καθ' όλη τη διάρκεια της ερευνητικής διαδικασίας ακολουθήθηκε μια ανθρωποκεντρική προσέγγιση με τους καθηγητές των MOOC να συμπεριλαμβάνονται τόσο στον ορισμό των ερευνητικών προβλημάτων, όσο και στο σχεδιασμό και τη βελτίωση των προτάσεων της διατριβής.

1. Εισαγωγή

Η συνεχής εξέλιξη της τεχνολογίας επηρεάζει κάθε πτυχή της καθημερινότητάς στον τρόπο που ενεργούμε, εργαζόμαστε και επικοινωνούμε. Στον εκπαιδευτικό τομέα, οι τεχνολογικές αλλαγές επηρεάζουν την διδασκαλία και μάθηση. Η τεχνολογική ανάπτυξη, για παράδειγμα, οδήγησε σε μια μετατόπιση από τα παραδοσιακά μοντέλα μάθησης (μάθηση σε τάξη) στην υιοθέτηση στρατηγικών εξ' αποστάσεως μάθησης (Yang & Kinshuk, 2016), μεταξύ των οποίων συναντάμε τα λεγόμενα «*Μαζικά Ανοικτά Διαδικτυακά Μαθήματα*» (**MOOC**) (Siemens, 2013).

Ο όρος MOOC περιγράφει ψηφιακά εκπαιδευτικά μαθήματα μέσω του Διαδικτύου. Τα διαδικτυακά αυτά μαθήματα προέκυψαν στο πλαίσιο του κινήματος ανοιχτής εκπαίδευσης, που συνεπάγεται την πρόσβαση σε υψηλής ποιότητας εκπαιδευτικό περιεχόμενο από ανθρώπους όλων των ηλικιών χωρίς γεωγραφικούς ή οικονομικού περιορισμούς (Siemens, 2013; UNESCO, 2019; Yang & Kinshuk, 2016). Από την εμφάνισή τους στο εκπαιδευτικό τοπίο, τα MOOCs έγιναν αντιληπτά ως ένα μέσο εκδημοκρατισμού της εκπαίδευσης παρέχοντας μαθησιακό περιεχόμενο πανεπιστημίων κύρους για άτομα που πιθανώς δεν μπορούσαν να ανταπεξέλθουν οικονομικά σε εναλλακτικές λύσεις μάθησης (Dillahunt, Wang, & Teasley, 2014; Moura, Souza, Oliveira Neto, & Viana, 2017). Ο David Cormier και ο Bryan Alexander επινόησαν τον όρο το 2008 για να περιγράψουν το διαδικτυακό μάθημα «*Connectivism and Connective Knowledge*» (Cormier & Siemens, 2010). Τα βασικά χαρακτηριστικά των MOOC είναι τα κάτωθι, βάσει του ίδιου του όρου:

— ***Μαζικά***: Η πρώτη έννοια αναφέρεται στη δυνατότητα συμμετοχής σε εκπαιδευτικό περιεχόμενο σε έναν απεριόριστο αριθμό χρηστών που μπορούν να αλληλεπιδράσουν ταυτόχρονα με το περιεχόμενο του μαθήματος (Siemens, 2013; Yousef, Chatti, Schroeder, Wosnitza, & Jakobs, 2015).

— ***Ανοιχτά***: Ο όρος «ανοιχτά» αφορά τον τρόπο πρόσβασης στο εκπαιδευτικό υλικό. Οι πλατφόρμες MOOC επιτρέπουν τη συμμετοχή στο ψηφιακό μάθημα χωρίς γεωγραφικούς ή οικονομικούς περιορισμούς (Onah et al., 2014b; Siemens, 2013; Yousef et al., *2015*). Υπάρχουν ορισμένες πλατφόρμες, όπως το Coursera, οι οποίες επιβάλλουν πρόσθετες χρεώσεις για ορισμένες επιλογές (για παράδειγμα, βαθμολογία στις εργασίες, διαπίστευση), ωστόσο το κύριο μέρος του μαθήματος παραμένει δωρεάν.

— ***Διαδικτυακά***: Ο όρος «διαδικτυακά» περιγράφει τη μορφή των μαθημάτων που διεξάγονται αποκλειστικά μέσω Διαδικτύου (Siemens, 2013; Yousef et al., 2015). Τα MOOC περιλαμβάνουν μια ποικιλία

ψηφιακού περιεχομένου (βίντεο, έγγραφα, ερωτηματολόγια, προσομοιώσεις, κ.λπ.) και ευκαιρίες αλληλεπίδρασης των μαθητών.
— ***Μαθήματα***: Τα MOOC αφορούν ένα δομημένο σύνολο μαθημάτων που ασχολούνται με ένα συγκεκριμένο θέμα, συνήθως οργανωμένα σε εβδομαδιαίες ενότητες με συγκεκριμένους μαθησιακούς στόχους και μεθόδους αξιολόγησης (Siemens, 2013; Yousef et al. , 2015). Υπάρχουν δύο βασικοί τύποι των MOOC: α) τα MOOC που είναι καθοδηγούμενα από τους διδάσκοντες και β) τα αυτορυθμιζόμενα MOOC (Calonge, Riggs, Shah, & Cavanagh, 2018). Ο πρώτος τύπος εξετάζει μαθήματα με προκαθορισμένο χρονοδιάγραμμα, σταθερή περίοδο έναρξης και δραστηριότητες που πρέπει να ολοκληρώσουν οι μαθητές σε συγκεκριμένες ημερομηνίες. Ο δεύτερος τύπος περιλαμβάνει μαθήματα με ευέλικτο χρονοδιάγραμμα, όπου το εκπαιδευτικό υλικό είναι πάντα διαθέσιμο και οι μαθητές μπορούν να προσαρμόσουν και να οργανώσουν τη μαθησιακή τους διαδρομή ανάλογα με τις ανάγκες τους.

Τα MOOCs έχουν ποικίλα πλεονεκτήματα τόσο για μαθητές όσο και για καθηγητές καθώς υποστηρίζουν λύσεις δια βίου μάθησης και επαγγελματικής ανάπτυξης (Brown, 2018; Shapiro et al., 2017). Οι μαθητές αναφέρουν ανάμεσα στους λόγους εγγραφής σε ένα MOOC τη μελέτη ενός νέου θέματος, την εξειδίκευση, την ανανέωση ή την πιστοποίηση των γνώσεών τους (Hew & Cheung, 2014; Shapiro et al., 2017). Επιπλέον, ο ανοιχτός χαρακτήρας τους προωθεί τις συνδέσεις και τις συνεργασίες μεταξύ συμμετεχόντων (Ferguson & Sharples, 2014) και έτσι ενθαρρύνει τη δημιουργία διαφορετικών κοινοτήτων μάθησης και πρακτικής. Ταυτόχρονα, οι καθηγητές των MOOC μπορούν να επεκτείνουν τις διδακτικές τους πρακτικές σε ψηφιακά και μαζικά περιβάλλοντα και να αποκτήσουν επαγγελματική προβολή. Δεδομένης της εξ' αποστάσεως μάθησης που προσφέρουν, η πανδημία COVID-19 προώθησε την υιοθέτηση των MOOCs σε παγκόσμιο επίπεδο σε όλες τις εκπαιδευτικές βαθμίδες συμπεριλαμβανομένης και της πρωτοβάθμιας (Chen et al., 2020; Ma & Rindlisbacher, 2020).

Παρά τις δυνατότητές τους, τα MOOC ακολουθούνται από πολλές προκλήσεις. Συγκεκριμένα, τα μαθήματα έχουν επικριθεί για τα υψηλά ποσοστά εγκατάλειψης των μαθητών και τη χαμηλή ποιότητα του παιδαγωγικού και διδακτικού σχεδιασμού (Aldowah, Al-Samarraie, Alzahrani, & Alalwan, 2020; Ferguson & Sharples, 2014). Μεταξύ των προαναφερθέντων προκλήσεων, η τρέχουσα διατριβή εστιάζει στις δυσκολίες σχεδιασμού και παροχής **εξατομικευμένης ανατροφοδότησης**, που αφορούν μια συνεχιζόμενη πρόκληση στα MOOC την τελευταία δεκαετία (Aldowah et al., 2020; Estrada-Molina & Fuentes-Cancell, 2022; Sari et al., 2020). Η ανατροφοδότηση αναγνωρίζεται ως θεμελιώδης πτυχή της μαθησιακής

διαδικασίας (Sawyer, 2006). Στα MOOC η απουσία εξατομικευμένης και έγκαιρης ανατροφοδότησης έχει συσχετιστεί και με την εγκατάλειψη των μαθημάτων από τους μαθητές (Aldowah et al., 2020; Gregori et al., 2018; Henderikx et al., 2017; Hone & El Said, 2016; Khalil & Ebner , 2014; Onah et al., 2014a; Refaat & Said, 2017) και την χαμηλή διδακτική ποιότητα των μαθημάτων (Aldowah et al., 2020; Margaryan et al., 2015).

Οι Hattie & Timperley (2007) ορίζουν την ανατροφοδότηση ως την πληροφορία που παρέχεται στον μαθητή σχετικά με την απόδοση ή κατανόησή του. Η ανατροφοδότηση θεωρείται απαραίτητη κατά τη διάρκεια της μαθησιακής διαδικασίας (Sawyer, 2006) με οφέλη και για τους μαθητές και για τους διδάσκοντες. Μέσω της ανατροφοδότησης οι διδάσκοντες μπορούν να βελτιώσουν τις διδακτικές πρακτικές τους και οι μαθητές να βελτιώσουν την απόδοσή τους και να αναπτύξουν ικανότητες, όπως δεξιότητες αυτορρύθμισης (Molloy & Boud, 2014).

Η παροχή έγκαιρης και εξατομικευμένης ανατροφοδότησης είναι μία από τις κύριες προκλήσεις για τους καθηγητές των MOOC (Pappano, 2012; Sari, Bonk, & Zhu, 2020). Τα φόρουμ συζήτησης αντιπροσωπεύουν τον πρωταρχικό χώρο όπου οι μαθητές επικοινωνούν τα προβλήματά τους και λαμβάνουν ανατροφοδότηση στα MOOC (Almatrafi, Johri, & Rangwala, 2018; Onah, Sinclair, & Boyatt, 2014b). Ωστόσο, η χρήση των φόρουμ ως το κύριο μέσο για την παροχή βοήθειας στους μαθητές συνοδεύεται από αρκετούς περιορισμούς λόγω: α) της δυσαναλογίας μαθητών-διδασκόντων, β) της διαφορετικότητας των γνώσεων και των πολιτισμικών πτυχών των μαθητών, γ) η περιορισμένη συμμετοχή σε φόρουμ συζήτησης από τους μαθητών (λιγότερο του 10% των μαθητών επικοινωνούν τα προβλήματά τους μέσω του φόρουμ) (Onah et al., 2014b; Wise & Cui, 2018).

Η χρήση των μαθησιακών δεδομένων μέσω των **Learning Analytics (LA)** μπορεί να συνδράμει στην παροχή εξατομικευμένης και έγκαιρης ανατροφοδότησης στα MOOC. Τα LA ορίζονται ως «*η μέτρηση, η συλλογή, η ανάλυση και η αναφορά ψηφιακών δεδομένων σχετικά με τους μαθητές με σκοπό την κατανόηση και βελτιστοποίηση της διαδικασίας μάθησης*» (Long & Siemens, 2011, σ. 34). Με άλλα λόγια, τα LA βασίζονται στην ανάλυση των ψηφιακών συμπεριφορών των μαθητών βάσει της αλληλεπίδρασής τους με τις ψηφιακές πλατφόρμες (π.χ., ο χρόνος που αφιέρωσαν σε ένα τεστ, οι φορές που επισκέφτηκαν το τεστ, κτλ.). Στην περίπτωση των MOOC, τα LA έχουν χρησιμοποιηθεί, μεταξύ άλλων σε ψηφιακούς πίνακες που οπτικοποιούν την πρόοδο των μαθητών (Arnold & Pistilli, 2012) ή σε μοντέλα πρόβλεψης συμπεριφορών μαθητών που κινδυνεύουν να εγκαταλείψουν το μάθημα (Bouzayane & Saad, 2017; Halawa, Greene, & Mitchell, 2014; Xing , Chen, Stein, & Marcinkowski, 2016; Yang, Sinha, Adamson, & Rose, 2013).

Οι κατάλληλες και ουσιαστικές παρεμβάσεις ανατροφοδότησης μέσω LA απαιτείται να βασίζονται σε **θεωρίες μάθησης** (Jivet, Scheffel, Drachsler, & Specht, 2017; Matcha, Uzir, Gasevic, & Pardo, 2020; Papamitsiou, Giannakos, & Ochoa, 2020) και να **συμμερίζονται τα ιδιαίτερα χαρακτηριστικά του κάθε μαθήματος** (Liu, Bartimote-Aufflick, Pardo, & Bridgeman, 2017· Shibani, Knight, & Shum, 2019). Επιπλέον, οι δυνατότητες των καθηγητών σχετικά με την ευκολία χειρισμού των πληροφοριών και των δεδομένων) θα πρέπει να λαμβάνονται υπόψη στο σχεδιασμό των εργαλείων LA (Chatti et al., 2020). Ωστόσο, πολλές φορές οι καθηγητές στερούνται γνώσεων και/ή υπάρχει αναντιστοιχία μεταξύ των πραγματικών αναγκών τους και των πληροφοριών που παρέχονται από τα εργαλεία LA (Fernández-Nieto, Buckingham Shum, & Martínez-Maldonado, 2022; Rienties, Herodotou, Olney, Schencks , & Borowa, 2018). Οι Rodríguez-Triana, Prieto, Martínez-Monés, Asensio-Pérez, & Dimitriadis (2018) πρότειναν ότι η εμπλοκή των καθηγητών, ως ειδικών του μαθήματος, θα μπορούσε να επιτρέψει πιο ενημερωμένες αποφάσεις για τα LA εργαλεία (δηλαδή αποφάσεις σχεδιασμού διδασκαλίας σχετικά με πτυχές μαθημάτων στο πλαίσιο ενός παιδαγωγικού σεναρίου).

Η τρέχουσα διατριβή εστιάζει στην ανατροφοδότηση **που σχεδιάζεται και παρέχεται από τους καθηγητές των MOOC** ως γνώστες των μαθημάτων τους, και τον τρόπο με τον οποίο η ανατροφοδότηση βασίζεται: (α) **στις ανάγκες των μαθητών,** (β) **στα χαρακτηριστικά του μαθήματος**, (γ) **σε παιδαγωγικές θεωρίες** και (δ) **στην αποφυγή υπερφόρτωσης των καθηγητών** (Figure 1.1)**.**

2. Στόχοι και Προτάσεις Διατριβής

Η παρούσα διατριβή πραγματεύεται το ακόλουθο ερευνητικό ερώτημα: ***Πώς θα μπορούσαν να υποστηριχθούν οι καθηγητές στο σχεδιασμό και την παροχή εξατομικευμένης ανατροφοδότησης στα MOOC με βάση τα LA;***

Τρεις επιμέρους στόχοι βοηθούν να απαντηθεί το άνωθεν ερώτημα.

(1) **Να εξεταστούν οι τεχνολογικές προτάσεις και τα εργαλεία που υποστηρίζουν τους καθηγητές στην παροχή ανατροφοδότησης βάσει των LA στα MOOC.**

Όπως αναφέρθηκε παραπάνω, η χρήση εργαλείων LA μπορούν να εξασφαλίσουν την παροχής εξατομικευμένης και έγκαιρης ανατροφοδότησης στα MOOC. Για να κατανοήσουμε τον αντίκτυπο τους, είναι σημαντικό να γνωρίζουμε τις δυνατότητες που προσφέρουν τα τρέχοντα τεχνολογικά εργαλεία, εάν είναι παιδαγωγικά θεμελιωμένα, εάν λαμβάνουν υπόψη το μαθησιακό πλαίσιο, κ.λπ. Αρκετές συστηματικές βιβλιογραφικές ανασκοπήσεις συζητούν τις δυνατότητες των LA για ανατροφοδότηση στην τριτοβάθμια και εξ' αποστάσεως μάθηση (Avella, Kebritchi, Nunn, & Kanai,

2016; Cavalcanti et al., 2021; Chiappe & Rodríguez, 2017; Lim, Gasevic, Matcha, Ahmad Uzir, & Dawson, 2021· Mangaroska & Giannakos, 2019· Schwendimann et al., 2017· Sharma, Giannakos, & Dillenbourg, 2020· Sunar, Abdullah, White, & Davis, 2016). Ωστόσο, υπάρχει έλλειψη συστηματικών βιβλιογραφικών ανασκοπήσεων σχετικά με τη χρήση εργαλείων LA για το σχεδιασμό και την αυτοματοποίηση της ανατροφοδότησης στα MOOC. Κατά συνέπεια, θεωρούμε απαραίτητη τη διεξαγωγή μιας συστηματικής βιβλιογραφικής ανασκόπησης σχετικά με το θέμα. Αυτή η συστηματική βιβλιογραφική ανασκόπηση είναι η πρώτη πρόταση αυτής της διατριβής, που στοχεύει να καταγράψει τον τρόπο με τον οποίο παρέχεται ανατροφοδότηση βάσει των LA στα MOOC.

***(2)* Να υποστηριχθούν οι καθηγητές στη διαμόρφωση εξατομικευμένης ανατροφοδότησης στα MOOC.**

Προηγούμενοι ερευνητές πρότειναν μοντέλα και εργαλεία LA για την αυτοματοποίηση της παροχής εξατομικευμένης ανατροφοδότησης με ενεργό συμμετοχή των καθηγητών στο σχεδιασμό τους (δηλαδή, L.I.M.E, OnTask, SRES, MOOClet πλαίσιο) (Burgos & Corbí, 2014; Liu et al., 2017; Pardo et al., 2018; Reza, Kim, Bhattacharjee, Rafferty, & Williams, 2021). Ωστόσο, τα εργαλεία αυτά δεν καθοδηγούν παιδαγωγικά τους διδάσκοντες στον σχεδιασμό της ανατροφοδότησης. Για παράδειγμα, δεν υπάρχει καθοδήγηση σχετικά με τον τρόπο υποστήριξης των μαθητών (π.χ., αναλυτική επίλυση του προβλήματος, παροχή επιπλέον ασκήσεων) ή με τον χρόνο ανατροφοδότησης (άμεση ανατροφοδότηση ή ετεροχρονισμένη). Επιπροσθέτως, τα προτεινόμενα εργαλεία δεν υποστηρίζουν τους διδάσκοντες, ειδικά τους λιγότερο έμπειρους, στην χρήση των LA.

Για να ικανοποιήσουμε τον δεύτερο στόχο προτείνουμε ένα εννοιολογικό πλαίσιο που αποσκοπεί στο να καθοδηγήσει τους καθηγητές στο σχεδιασμό και την παροχή παρεμβάσεων ανατροφοδότησης βάσει των LA. Το εννοιολογικό πλαίσιο απαρτίζεται από:

- μια κατευθυντήρια διαδικασία ως σύνολο υποδείξεων για την βήμα προς βήμα καθοδήγηση των καθηγητών αναφορικά με τον σχεδιασμό ανατροφοδότησης (για παράδειγμα, αρχικά οι καθηγητές θα πρέπει να κάνουν ένα σχεδιάγραμμα του μαθήματός τους, έπειτα να σκεφτούν πιθανά προβλήματα μαθητών κτλ.).
- τρεις καταλόγους με πιθανά προβλήματα μαθητών στα MOOC (όπως, δυσκολίες κατανόησης μιας δραστηριότητας), ψηφιακά δεδομένα που μπορούν να βοηθήσουν στον εντοπισμό των μαθητών που αντιμετωπίζουν αυτά τα προβλήματα (όπως, ο χρόνος που οι μαθητές αφιέρωσαν σε μια δραστηριότητα) και

ιδέες για τρόπους ανατροφοδότησης (όπως, παροχή επιπλέον θεωρητικού υλικού).

- ένα σύνολο προτάσεων που λειτουργούν ως «καλές πρακτικές» για τη διαμόρφωση πιο στοχευμένων παρεμβάσεων. Για παράδειγμα, για να αντιμετωπιστεί το πρόβλημα της κατανόησης μιας θεωρίας προτείνεται άμεση παροχή επιπλέον ασκήσεων.

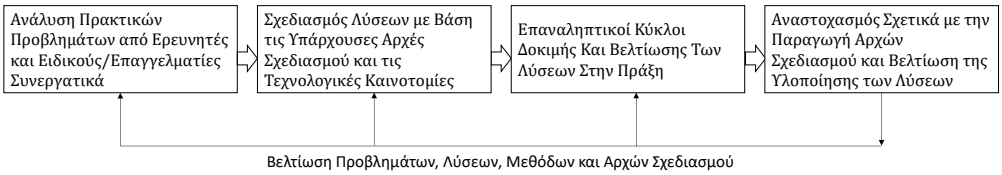
***(3)* Να βοηθηθούν οι καθηγητές ώστε να καταστεί διαχειρίσιμος ο σχεδιασμός της ανατροφοδότησης για MOOC.**

Ο σχεδιασμός της ανατροφοδότησης συνεπάγεται επιπρόσθετο φόρτο εργασίας (από άποψη χρόνου και προσπάθειας) στις ήδη υπάρχουσες αρμοδιότητες των διδασκόντων. Ως εκ τούτου, θεωρήσαμε απαραίτητο να παρέχουμε αυτόματη υποστήριξη στους διδάσκοντες, ώστε οι παρεμβάσεις που σχεδιάζουν μέσω του εννοιολογικού πλαισίου που προτείνουμε να μην είναι χρονοβόρες. Η προτεινόμενη συνεισφορά της διατριβής για την επίτευξη αυτού του στόχου αφορά ένα σύνολο οδηγιών για την ενσωμάτωση του εννοιολογικού πλαισίου σε τεχνολογικά εργαλεία που θα κάνουν τη διαδικασία ερμηνεύσιμη από τον υπολογιστή.

3. Μεθοδολογία

Για την επίτευξη των στόχων της παρούσας διατριβής ακολουθείται ως μεθοδολογία η *Έρευνα Βασισμένη στη Σχεδίαση* (Design-Based Research) (Amiel & Reeves, 2008). Η συγκεκριμένη μεθοδολογία στοχεύει να βοηθήσει στην επίλυση εκπαιδευτικών προβλημάτων μέσω της στενής συνεργασίας μεταξύ ερευνητών και ειδικών/επαγγελματιών (π.χ., καθηγητές). Σύμφωνα με αυτή τη μέθοδο, η ερευνητική διαδικασία αναπτύσσεται στα ακόλουθα στάδια (Εικόνα 1):

i. Ανάλυση πρακτικών προβλημάτων από ερευνητές και ειδικούς/επαγγελματίες συνεργατικά,
ii. Σχεδιασμός λύσεων με βάση τις υπάρχουσες αρχές σχεδιασμού και τις τεχνολογικές καινοτομίες,
iii. Επαναληπτικοί κύκλοι δοκιμής και βελτίωσης των λύσεων στην πράξη,
iv. Αναστοχασμός σχετικά με την παραγωγή αρχών σχεδιασμού και βελτίωση της υλοποίησης των λύσεων.



Εικόνα 1. Μεθοδολογική προσέγγιση Έρευνας Βασισμένης στη Σχεδίαση (Amiel & Reeves, 2008).

Η συγκεκριμένη μεθοδολογία εφαρμόζεται επαναληπτικά με στόχο τη σταδιακή βελτίωση των λύσεων που αναπτύσσονται. Αυτός ο επαναληπτικός χαρακτήρας στην συγκεκριμένη διατριβή οδήγησε σε τέσσερις κύκλους έρευνας. Συγκεκριμένα:

- *Στον πρώτο κύκλο*, πραγματοποιήθηκε ανάλυση του προβλήματος μέσω ανασκόπησης της βιβλιογραφίας και μέσω δύο διερευνητικών μελετών σε ένα MOOC του Πανεπιστημίου του Valladolid σχετικά με τα προβλήματα που αντιμετωπίζουν οι μαθητές στα MOOC και τις τακτικές αντιμετώπισης των προβλημάτων τους. Πραγματοποιήσαμε επίσης μια διερευνητική μελέτη με 14 ημιδομημένες συνεντεύξεις με καθηγητές MOOC για να εντοπίσουμε τις ανάγκες τους στην παροχή ανατροφοδότησης. Από την ανάλυση προέκυψε η ανάγκη εννοιολογικών και τεχνολογικών εργαλείων για την υποστήριξη των καθηγητών MOOC στον εντοπισμό των μαθητών που αντιμετωπίζουν προβλήματα κατά το μάθημα και στην παροχή εξατομικευμένων παρεμβάσεων ανατροφοδότησης. Σε αυτόν τον κύκλο δημιουργήθηκε και η πρώτη εκδοχή του εννοιολογικού πλαισίου για την υποστήριξη των καθηγητών. Κατά τη διάρκεια αυτού του κύκλου, έγιναν 2 μελέτες με καθηγητές MOOC, που μας βοήθησαν να αξιολογήσουμε και να βελτιώσουμε το ερευνητικό πλαίσιο.

- *Στον δεύτερο κύκλο*, εξετάσαμε τη βιβλιογραφία σχετικά με τις παιδαγωγικές θεωρίες ανατροφοδότησης για να συνθέσουμε τους καταλόγους και τις κατευθυντήριες γραμμές του εννοιολογικού πλαισίου. Επιπλέον, πραγματοποιήθηκε η χρήση του εννοιολογικού πλαισίου σε ένα MOOC. Η μελέτη ακολούθησε όλες τις φάσεις του μαθήματος: από την αρχική φάση, κατά την οποία το πλαίσιο χρησιμοποιήθηκε μαζί με τον καθηγητή του μαθήματος για τον εντοπισμό πιθανών προβλημάτων που θα μπορούσαν να έχουν οι μαθητές και τα ψηφιακά δεδομένα για την ανίχνευσή τους, μέχρι την τελική αξιολόγηση του αντίκτυπου του πλαισίου για την παροχή ανατροφοδότησης. Αυτή η εμπειρία χρησίμευσε στον εμπλουτισμό του ερευνητικού πλαισίου.

- *Στον τρίτο κύκλο*, εστιάσαμε στο να μειώσουμε τον χρονοβόρο χαρακτήρα της διαδικασίας για τους καθηγητές. Η εμπειρία του προηγούμενου κύκλου έδειξε την ανάγκη εξοικονόμησης χρόνου από τους καθηγητές στη διαδικασία σχεδιασμού της παροχής υποστήριξης. Κατά τη διάρκεια αυτού του κύκλου, ξεκίνησε η ενσωμάτωση του εννοιολογικού πλαισίου σε ένα τεχνολογικό εργαλείο, ένα σύστημα, στόχος του οποίου είναι να αυτοματοποιήσει τη διαδικασία του

πλαισίου και να διευκολύνει το έργο του σχεδιασμού της παροχής ανατροφοδότησης στους καθηγητές.

- *Στον τέταρτο κύκλο*, βασιζόμενοι στη βιβλιογραφία και τις προηγούμενες εμπειρίες αξιολόγησης, δημιουργήσαμε το σύνολο προτάσεων που περιλαμβάνονται στο εννοιολογικό πλαίσιο και επιπλέον βελτιώσαμε τις κατευθυντήριες γραμμές του πλαισίου. Κατά τη διάρκεια αυτού του κύκλου, διεξήχθη η τελική αξιολόγηση του FeeD4Mi με καθηγητές MOOC, όπου εφαρμόσαμε το εννοιολογικό πλαίσιο στα δικά τους μαθήματα. Μέσω αυτής της εμπειρίας αξιολογήσαμε τη χρησιμότητα και χρησιμότητα του πλαισίου.

Όπως προβλέπεται από τη μεθοδολογία, τα αποτελέσματα κάθε κύκλου έχουν δημοσιευτεί σε έγκριτα συνέδρια και περιοδικά.

4. Διερευνητικές Μελέτες

Η συγκεκριμένη ενότητα εξετάζει τις διερευνητικές μελέτες που πραγματοποιήθηκαν κατά τη διάρκεια της διατριβής. Συνολικά, πραγματοποιήσαμε τρεις διερευνητικές μελέτες στις οποίες συμμετείχαν τόσο καθηγητές όσο και μαθητές των MOOC. Αυτή η προσέγγιση επέτρεψε μια βαθύτερη κατανόηση των αναγκών των πρωταγωνιστών της διαδικασίας μάθησης. Οι δύο πρώτες διερευνητικές μελέτες επικεντρώθηκαν στα προβλήματα που αντιμετωπίζουν οι μαθητές κατά τη διάρκεια του μαθήματος και στη συμπεριφορά τους όταν προσπαθούν να ξεπεράσουν τα προβλήματά τους. Η τρίτη διερευνητική μελέτη στόχευσε τους καθηγητές των MOOC και κατέδειξε τις στρατηγικές που χρησιμοποιούν και τις προκλήσεις που αντιμετωπίζουν σε σχέση με το σχεδιασμό και την παροχή ανατροφοδότησης.

Οι δύο πρώτες μελέτες πραγματοποιήθηκαν στο MOOC *Por los mares de la traducción económico-financiera* 2ed (EN-ES)[19] από τον Μάρτιο έως τον Ιούνιο του 2018. Το μάθημα πραγματεύτηκε την μετάφραση οικονομικών και επιχειρηματικών όρων μεταξύ αγγλικής και ισπανικής γλώσσας. Το MOOC περιείχε επτά εβδομαδιαίες ενότητες με διαλέξεις video, δύο διαφορετικά φόρουμ (δηλαδή φόρουμ γενικής συζήτησης και φόρουμ συζήτησης ομαδικών δραστηριοτήτων), κοινωνικά δίκτυα (όπως, Facebook) και διάφορες ατομικές και ομαδικές εργασίες υποχρεωτικού και προαιρετικού χαρακτήρα. Ο εκτιμώμενος φόρτος εργασίας ήταν 3 ώρες την εβδομάδα. Από τους 866 μαθητές που εγγράφηκαν στο μάθημα, οι 169 έλαβαν το πιστοποιητικό επιτυχούς παρακολούθησης (19,52% ποσοστό ολοκλήρωσης). Απαραίτητη

[19] https://www.classcentral.com/course/canvas-network-por-los-mares-de-la-traduccion-economico-financiera-2ed-en-es-8014, Τελευταία πρόσβαση: Νοέμβριος 2022

προϋπόθεση για την απόκτηση του πιστοποιητικού ήταν η ολοκλήρωση όλων των υποχρεωτικών εργασιών. Οι δυο πρώτες μελέτες εξερεύνησαν τα ακόλουθα ερωτήματα αντίστοιχα: «*Ποια προβλήματα αντιμετωπίζουν οι μαθητές σε ένα MOOC;*» και «*Σε ποιο βαθμό η ψηφιακή συμπεριφορά των μαθητών παρέχει χρήσιμες πληροφορίες για τον εντοπισμό αυτών που αντιμετωπίζουν προβλήματα κατά τη διάρκεια ενός MOOC;*».

Η τρίτη διερευνητική μελέτη πραγματοποιήθηκε από τον Οκτώβριο έως τον Δεκέμβριο του 2018 και απαρτίστηκε από ένα σύνολο συνεντεύξεων με καθηγητές MOOC. Η συγκεκριμένη μελέτη στόχευε να ρίξει φως στις πρακτικές και τις προκλήσεις των καθηγητών MOOC κατά τη διαδικασία παροχής ανατροφοδότησης στους μαθητές κατά τη διάρκεια του μαθήματος. Η μελέτη περιέλαβε 14 ημιδομημένες συνεντεύξεις με καθηγητές και υπευθύνους επιβλέποντες σχεδιασμού των μαθημάτων σε MOOC. Η τρίτη μελέτη ερεύνησε το ακόλουθο ερώτημα: «*Ποια είναι η εμπειρία των καθηγητών στη διαδικασία παροχής βοήθειας και υποστήριξης σε μαθητές που αντιμετωπίζουν δυσκολίες στα MOOCs;*»

Από την ανάλυση των μελετών προέκυψαν αρκετά κοινά προβλήματα που μπορούν να αντιμετωπίσουν οι μαθητές και να λειτουργήσουν ως τροχοπέδη στα MOOC, όπως δυσκολίες λόγω έλλειψης γνώσεων, ζητήματα που σχετίζονται με την κατανόηση του μαθήματος και των δραστηριοτήτων, έλλειψη έγκαιρης ανατροφοδότησης κ.α. Αυτά τα προβλήματα ήταν κοινά ανεξαρτήτως του μαθήματος (π.χ., Πληροφορική ή Ιστορία). Τα ευρήματά μας σχετικά με τα προβλήματα των μαθητών στα MOOC συμφωνούν με προηγούμενες εργασίες των Gütl et al. (2014), Henderikx et al. (2018), Hone & El Said (2016) και Loizzo et al (2017). Ως αποτέλεσμα, θεωρούμε ότι η παροχή ενός συνόλου προβλημάτων θα μπορούσε να προετοιμάσει τους καθηγητές για τον σχεδιασμό εξατομικευμένων παρεμβάσεων εκ των προτέρων.

Επιπλέον, εντοπίσαμε πως υπάρχει έλλειψη βασικών γνώσεων εκ μέρους των καθηγητών MOOC για την κατανόηση των πληροφοριών βάσει των LA και έλλειψη εργαλείων για την καθοδήγηση τους στη χρήση των LA. Αυτό το εύρημα είναι σύμφωνο με τις έρευνες των Fernández-Nieto et al. (2022), Matcha et al. (2020) και Rienties et al. (2018), οι οποίες ανέδειξαν τις δυσκολίες τόσο των μαθητών όσο και των καθηγητών στην ερμηνεία των δεδομένων LA. Επιπλέον, οι Mangaroska & Giannakos (2019) πρότειναν την δημιουργία πλαισίων και εννοιολογικών εργαλείων που θα βοηθήσουν τους καθηγητές να κατανοήσουν και να εφαρμόσουν τις πληροφορίες LA και να τις συνδέσουν με τις ανάγκες του μαθήματός τους.

Αντίστοιχα, οι τρεις μελέτες κατέδειξαν πως συχνά τα διαθέσιμα εργαλεία LA δεν είναι χρήσιμα για παροχή εξατομικευμένης βοήθειας κατά τη διάρκεια

του μαθήματος, επειδή συλλέγουν δεδομένα των μαθητών χωρίς να εξετάζουν το ίδιο το περιεχόμενο του μαθήματος. Για παράδειγμα, εξετάζουν τον χρόνο που ένας μαθητής αφιέρωσε σε μια δραστηριότητα χωρίς να λαμβάνουν υπόψιν τη δυσκολία της δραστηριότητας. Ως αποτέλεσμα, θεωρούμε πως χρειάζεται να διερευνηθεί εάν η συμμετοχή των καθηγητών στην επιλογή των μαθητικών δεδομένων θα μπορούσε να οδηγήσει σε πιο κατατοπιστικά αποτελέσματα. Κάτω από αυτό το πρίσμα, οι έρευνα των Pardo et al (2018) και Liu (2017) πρότειναν τη χρήση εργαλείων LA που επιτρέπουν στους καθηγητές να επιλέξουν τα ψηφιακά δεδομένα θεωρούν πιο σχετικά ώστε να παρέχουν πιο ουσιαστική ανατροφοδότηση στους μαθητές τους.

Τα αποτελέσματα των διερευνητικών μελετών οδήγησαν στον ορισμό των προτάσεων της διατριβής. Πιο συγκεκριμένα, οδήγησαν: α) στην ανάγκη μιας συστηματικής βιβλιογραφικής ανασκόπησης που να αποκαλύπτει την τρέχουσα κατάσταση σχετικά με τα τεχνολογικά εργαλεία για παροχή ανατροφοδότησης στα MOOC με την παρέμβαση του καθηγητή, και β) σε ένα εννοιολογικό πλαίσιο που στοχεύει να βοηθήσει τους καθηγητές των MOOC να διαμορφώσουν εξατομικευμένες παρεμβάσεις ανατροφοδότησης.

5. Προτάσεις Διατριβής

5.1. Συστηματική Βιβλιογραφική Ανασκόπηση

Η τρέχουσα ενότητα παρουσιάζει την συστηματική βιβλιογραφική ανασκόπηση που εκπονήθηκε για την κατανόηση των τεχνολογικών προτάσεων για παροχή ανατροφοδότησης βάσει των LA από τους καθηγητές στα MOOC. Η βιβλιογραφική ανασκόπηση αποτελεί την πρώτη πρόταση της διατριβής και στοχεύει στην επίτευξη του πρώτου στόχου που παρουσιάστηκε στην Ενότητα 2.

Η συστηματική βιβλιογραφική ανασκόπηση καθοδηγήθηκε από το ακόλουθο ερευνητικό ερώτημα: ***«Ποιες είναι οι σύγχρονες τάσεις σχετικά με την παροχή ανατροφοδότησης από καθηγητές στα MOOC βάσει των LA;».*** Για την καλύτερη διερεύνηση του ερωτήματος, εντοπίσαμε τις ακόλουθες τέσσερις υποερωτήσεις (Figure 4.3):

- *Ποια είναι η συνολική εικόνα της ανατροφοδότησης βάσει των LA στα MOOC σύμφωνα με τα πρόσφατα ερευνητικά δεδομένα;*
- *Πώς σχεδιάζεται η ανατροφοδότηση στα MOOC όσον αφορά τις παιδαγωγικές θεωρίες που ακολουθούνται;*
- *Πώς εφαρμόζονται τα LA στα MOOC για να καθοδηγήσουν την ανατροφοδότηση;*
- *Ποια είναι τα αποτελέσματα των παρεμβάσεων ανατροφοδότησης σε MOOC στην πράξη;*

Η βιβλιογραφική ανασκόπηση ακολούθησε τις κατευθυντήριες γραμμές που πρότειναν οι Kitchenham & Chartes (2007). Οι Kitchenham & Charters οργανώνουν τη διαδικασία της ανασκόπησης σε 3 φάσεις: στο σχεδιασμό της αναθεώρησης, στη διεξαγωγή της αναθεώρησης και στην αναφορά των αποτελεσμάτων. Σύμφωνα με τις αποφάσεις που ελήφθησαν κατά την πρώτη φάση από έναν συνολικό αριθμό 227 άρθρων, 38 δημοσιεύσεις θεωρήθηκαν σχετικές για συμπερίληψη στην βιβλιογραφική ανασκόπηση (Figure 4.4). Τα αποτελέσματα παρουσιάζονται ακολούθως.

Αναφορικά με το πρώτο υποερώτημα για την συνολική ερευνητική εικόνα της ανατροφοδότησης στα MOOC, τα στοιχεία που συγκεντρώθηκαν κατέδειξαν το ερευνητικό ενδιαφέρον για τη χρήση των LA με σκοπό τη διαμόρφωση παρεμβάσεων. Υψηλότερη προσοχή σημειώθηκε κατά τις περιόδους 2015-2018 και 2020-2021. Ο Lederman (2019) ερμήνευσε το μειούμενο ενδιαφέρον για τα MOOC ως απόρροια των χαμηλών ποσοστών ολοκλήρωσης των μαθημάτων. Παρομοίως, η μεταβολή των MOOC από ανοιχτό εκπαιδευτικό μοντέλο σε μοντέλο επικεντρωμένο σε διαπιστευτήρια επιπέδου προπτυχιακών και μεταπτυχιακών σπουδών θα μπορούσε να έχει επηρεάσει στην εναλλαγή του ερευνητικού ενδιαφέροντος (Reich & Ruipérez-Valiente, 2019). Τέλος, η πανδημία COVID-19 μετέβαλε το εκπαιδευτικό τοπίο και οδήγησε σε υιοθέτηση των MOOC σε όλα τα εκπαιδευτικά επίπεδα, ακόμη και στην πρωτοβάθμια εκπαίδευση (Chen et al., 2020; Impey & Formanek, 2021; Ma & Rindlisbacher, 2020). Ως εκ τούτου, υποθέτουμε ότι η κατάσταση του COVID-19 ενέτεινε την προσοχή στην παροχή ανατροφοδότησης σε μαζικά πλαίσια.

Σχετικά με τον σχεδιασμό της ανατροφοδότησης σύμφωνα με παιδαγωγικές θεωρίες, τα ευρήματά μας υποδηλώνουν την Αυτορυθμιζόμενη Μάθηση ως πιο κοινώς εφαρμοσμένη θεωρία στα MOOC. Κατά την Αυτορυθμιζόμενη Μάθηση, οι μαθητές πρέπει να ορίζουν αυτόνομα την μαθησιακή τους διαδικασία (Zimmerman, 2000). Τα αποτελέσματά μας συμφωνούν τους Khalil et al. (2022) σύμφωνα με τους οποίους, η Αυτορυθμιζόμενη Μάθηση είναι η κυρίαρχη θεωρία που ενημερώνει τις προτάσεις των LA στην τριτοβάθμια εκπαίδευση. Ωστόσο, από τις 38 δημοσιεύσεις που αναλύθηκαν, μόνο 8 ανέφεραν ένα συγκεκριμένο πλαίσιο ή θεωρία μάθησης. Ο συγκεκριμένος περιορισμός καταδεικνύει την έλλειψη εκπαιδευτικής βάσης για τα συστήματα ανατροφοδότησης και τις προβλεπόμενες παρεμβάσεις τους. Τα αποτελέσματά μας είναι συμβατά με τους Cavalcanti et al. (2021) και Jivet et al. (2017), οι οποίοι υπογράμμισαν τη γενική έλλειψη παιδαγωγικής βάσης στα εργαλεία LA που συναντώνται στην τριτοβάθμια εκπαίδευση και σε διαδικτυακά περιβάλλοντα μάθησης. Οι Ferguson & Sharples (2014) συσχέτισαν την απουσία παιδαγωγικών πλαισίων

στα MOOC με την μείωση ενδιαφέροντος των μαθητών και την αποχώρησή τους από το μάθημα.

Όσον αφορά την εφαρμογή των LA στα MOOC για το σχεδιασμό ανατροφοδότησης, τα στοιχεία που συγκεντρώθηκαν έδειξαν μια ποικιλία εργαλείων LA, έχοντας τα ψηφιακά δεδομένα των μαθητών ως κύρια πηγή για την ενημέρωση των παρεμβάσεων. Τα τεχνολογικά εργαλεία που αναπτύχθηκαν αφορούν κυρίως πίνακες, ή αυτοματοποιημένα συστήματα ανατροφοδότησης με τη μορφή υπενθυμίσεων, ενθαρρυντικών μηνυμάτων κ.λπ. Παρόλα αυτά, καμία από τις δημοσιεύσεις δεν προέβη στην παροχή οδηγιών για να διευκολυνθεί η κατανόηση και η εφαρμογή των πληροφοριών των LA από τους διδάσκοντες. Αξίζει να αναφερθεί ότι οι καθηγητές συχνά αντιμετωπίζουν δυσκολίες στην ερμηνεία και τη χρήση των πληροφοριών LA (Fernández-Nieto et al., 2022; Matcha et al., 2020; Rienties et al., 2018). Πράγματι, οι Mangaroska & Giannakos (2019) ανέφεραν ότι, παρόλο που υπάρχουν πολλά εργαλεία LA, οι καθηγητές εξακολουθούν να χρειάζονται καθοδήγηση για να κατανοήσουν και να χρησιμοποιήσουν τα LA στις μαθησιακές τους πρακτικές.

Τα αποτελέσματα των παρεμβάσεων ανατροφοδότησης δείχνουν έλλειψη εμπειρικών μελετών και αξιολογήσεων σε αυθεντικά μαθήματα. Συγκεκριμένα, μόνο 4 μελέτες ανέφεραν την εκπόνηση αξιολόγησης των τεχνολογικών και εννοιολογικών προτάσεών τους. Το γεγονός αυτό υποδηλώνει ότι το πεδίο βρίσκεται ακόμη σε πρώιμο στάδιο. Οι παρατηρήσεις μας συμφωνούν με την τρέχουσα κατάσταση των παρεμβάσεων των LA στην Τριτοβάθμια Εκπαίδευση (Tsai, 2017; Viberg, Hatakka, Bälter, & Mavroudi, 2018) και στα MOOC (Zhu, Sari, & Lee, 2022). Συμπερασματικά, υπάρχει μια γενική ανακολουθία μεταξύ των ερευνητικών προτάσεων και της εφαρμογής τους σε εκπαιδευτικές πρακτικές.

Συνοψίζοντας, τα αποτελέσματα υποδηλώνουν ότι το πεδίο εξελίσσεται δεδομένου του αυξανόμενου ενδιαφέροντος για το θέμα, της ποικιλίας των προτεινόμενων λύσεων και του αυξανόμενου αριθμού των ερευνητικών άρθρων. Ωστόσο, η ανασκόπηση υπέδειξε την έλλειψη εμπειρικών μελετών που διερευνούν τη χρήση των LA για την ενημέρωση της ανατροφοδότησης στα MOOC και για τη αξιολόγηση του αντίκτυπου αυτής της ανατροφοδότησης στην εκπαιδευτική πραγματικότητα. Επιπλέον, καταδείχτηκε η έλλειψη παιδαγωγικής υποστήριξης των εργαλείων LA για τη διαμόρφωση της ανατροφοδότησης. Τέλος, η βιβλιογραφική ανασκόπηση έδειξε ότι τα εργαλεία LA δεν παρέχουν καθοδήγηση στους διδάσκοντες για τον σχεδιασμό των στρατηγικών ανατροφοδότησης. Ένας τρόπος αντιμετώπισης αυτών των ζητημάτων θα μπορούσε να αφορά την ενεργό συμμετοχή των καθηγητών, όχι απλώς ως τελικούς χρήστες των εργαλείων

των LA αλλά ως συν-σχεδιαστές των εργαλείων. Για παράδειγμα, οι καθηγητές θα μπορούσαν να συνεπιλέγουν ή να ορίζουν τα ψηφιακά δεδομένα των μαθητών που θεωρούνται ως καταλληλότερα σύμφωνα με τα χαρακτηριστικά και τους στόχους του μαθήματος.

5.2. Εννοιολογικό Πλαίσιο *FeeD4Mi*

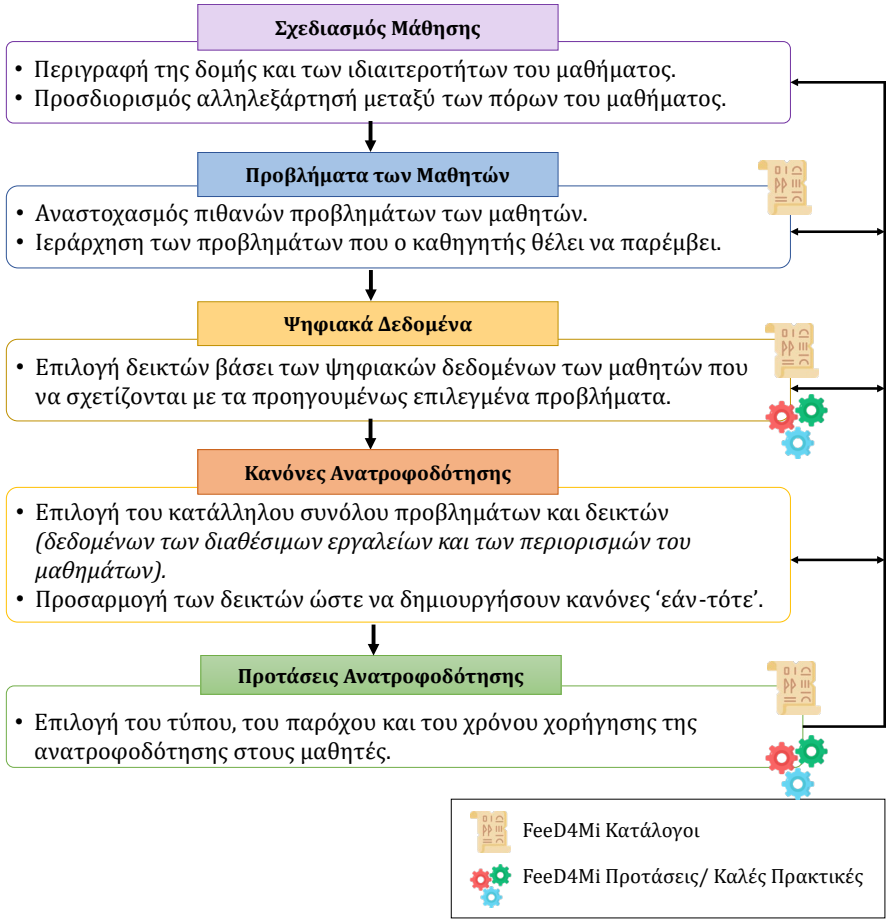
Η τρέχουσα ενότητα παρουσιάζει το εννοιολογικό πλαίσιο που αναπτύχτηκε κατά τη διάρκεια της διατριβής για παροχή ανατροφοδότησης βάσει των LA από τους καθηγητές στα MOOC. Το εννοιολογικό πλαίσιο αποτελεί την δεύτερη πρόταση της διατριβής και στοχεύει στην επίτευξη του δεύτερου και τρίτου ερευνητικού στόχου (βλ. Ενότητα 2).

Για την αντιμετώπιση των περιορισμών που εντοπίστηκαν προηγουμένως κατά τη συστηματική ανασκόπηση της βιβλιογραφίας (βλ. Ενότητα 5.1) και τις τρεις διερευνητικές μελέτες (βλ. Ενότητα 4), προτείνουμε το εννοιολογικό πλαίσιο *Feedback Design for MOOC Instructors, FeeD4Mi.* Το FeeD4Mi στοχεύει να βοηθήσει τους καθηγητές να αναστοχαστούν τις πρακτικές ανατροφοδότησης τους και στη συνέχεια να σχεδιάσουν τις παρεμβάσεις βάσει των ιδιαιτεροτήτων του μαθήματός τους. Η μεθοδολογική προσέγγιση που ακολουθήθηκε κατά την παρούσα διατριβή (βλ. Ενότητα 3) καθοδήγησε τον σχεδιασμό και τη διαδικασία ανάπτυξης του προτεινόμενου πλαισίου. Το FeeD4Mi αποτελείται από τα ακόλουθα στοιχεία:

- πέντε διαστάσεις που υποδεικνύουν τις παραμέτρους που πρέπει να ληφθούν υπόψη για το σχεδιασμό εξατομικευμένων παρεμβάσεων ανατροφοδότησης,
- μια διαδικασία βασισμένη σε κατευθυντήριες γραμμές για τον σχεδιασμό των παρεμβάσεων,
- τρεις καταλόγους με πιθανά προβλήματα μαθητών, προτάσεις ψηφιακών δεδομένων που μπορούν να βοηθήσουν στον εντοπισμό των μαθητών που αντιμετωπίζουν αυτά τα προβλήματα (π.χ., ο χρόνος που οι μαθητές αφιέρωσαν σε μια δραστηριότητα) και ιδέες υποστήριξης,
- ένα σύνολο προτάσεων που λειτουργούν ως «καλές πρακτικές» για τη διαμόρφωση πιο στοχευμένων παρεμβάσεων.
- ένα σύνολο οδηγιών σχεδιασμού για την ενσωμάτωση του πλαισίου σε τεχνολογικά εργαλεία.

Η Εικόνα 2 συνοψίζει το πλαίσιο FeeD4Mi και τις ενέργειες που προβλέπονται σε κάθε διάσταση. Πιο συγκεκριμένα, το πλαίσιο είναι οργανωμένο γύρω από τις ακόλουθες πέντε διαστάσεις:

1) ***Σχεδιασμός μάθησης:*** Η πρώτη διάσταση του FeeD4Mi περιγράφει τις ιδιαιτερότητες του μαθήματος (για παράδειγμα, δομή του μαθήματος, πόροι, συσχέτιση μεταξύ των πόρων) που πρέπει να αναστοχαστούν και να περιγράψουν οι καθηγητές. Συγκεκριμένα, οι καθηγητές καλούνται να περιγράψουν το μάθημά τους προσδιορίζοντας τη δομή της ενότητας, τη δυσκολία των ασκήσεων, τις δραστηριότητες που είναι ατομικές ή ομαδικές, υποχρεωτικές ή επιλογής, κ.α.
2) ***Προβλήματα των μαθητών:*** Η δεύτερη διάσταση του FeeD4Mi περιγράφει τα πιθανά προβλήματα που μπορούν να αντιμετωπίσουν οι μαθητές κατά τη διάρκεια του μαθήματος. Οι διερευνητικές μελέτες (βλ. Ενότητα 3) αποκάλυψαν ένα σύνολο προβλημάτων των μαθητών που είναι κοινά σε MOOC διαφορετικών κλάδων (για παράδειγμα, MOOCs Ιστορίας, Μαθηματικών). Θεωρούμε ότι η παροχή μιας λίστας τέτοιων προβλημάτων στους καθηγητές θα τους διευκολύνει κατά τον σχεδιασμό παρεμβάσεων ανατροφοδότησης. Τα προβλήματα των μαθητών (που εμπεριέχονται στους καταλόγους) μπορεί να σχετίζονται με ζητήματα κατανόησης, έλλειψη γνωστικού υποβάθρου, συνεργασία μεταξύ των συμμαθητών κ.α.



Εικόνα 2. Απεικόνιση της διαδικασίας FeeD4Mi.

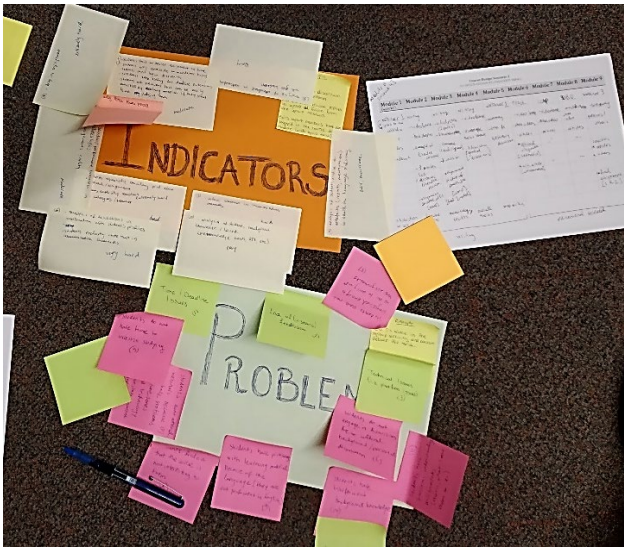
3) ***Ψηφιακά δεδομένα***: Η τρίτη διάσταση του FeeD4Mi αφορά την επιλογή δεικτών (όπως, χρόνος που αφιερώθηκε σε μια δραστηριότητα) για τον εντοπισμό συμπεριφορών πιθανών μαθητών που δυσκολεύονται. Αυτοί οι δείκτες βασίζονται στα ψηφιακά δεδομένα των μαθητών που δημιουργούνται κατά τη διάρκεια του μαθήματος μέσω της αλληλεπίδρασης με την πλατφόρμα μάθησης. Για παράδειγμα, ένα πρόβλημα κατανόησης περιεχομένου θα μπορούσε να εντοπιστεί παρατηρώντας χαμηλές βαθμολογίες σε μια δραστηριότητα ή πολλές προβολές του ίδιου video. Το FeeD4Mi προτείνει επίσης ένα σύνολο καταλόγων και προτάσεων που χρησιμεύουν για την καλύτερη επιλογή δεικτών.
4) ***Κανόνες ανατροφοδότησης:*** Η τέταρτη διάσταση του FeeD4Mi περιλαμβάνει τη δυνατότητα των καθηγητών να προσαρμόσουν τους δείκτες της προηγούμενης διάστασης ώστε να δημιουργήσουν κανόνες και συνθήκες 'εάν-τότε'. Για παράδειγμα, η προβολή ενός βίντεο πάνω

από 4 φορές μπορεί να θεωρηθεί αποδεκτή *εάν* η δυσκολία της δραστηριότητας είναι υψηλή και μπορεί να είναι προειδοποιητική *εάν* η δυσκολία της δραστηριότητας είναι χαμηλή.

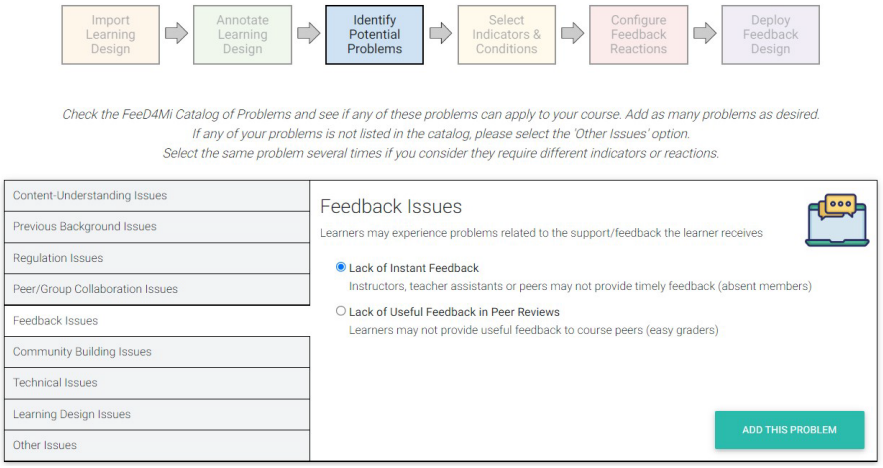
5) ***Προτάσεις ανατροφοδότησης:*** Η τελευταία διάσταση του FeeD4Mi σχετίζεται με τις διαφορετικές πτυχές ανατροφοδότησης που πρέπει να λάβουν υπόψη οι διδάσκοντες προκειμένου να διαμορφώσουν επιτυχημένες παρεμβάσεις ανατροφοδότησης. Αυτές οι πτυχές σχετίζονται με τον χρόνο της ανατροφοδότησης (καθυστερημένη ή άμεση), τα μέσα με τα οποία θα παραδοθεί η παρέμβαση (μέσω email, ειδοποίησης, μέσω του ίδιου του διδάσκοντα, κ.α.) και το είδος της παρέμβασης ανατροφοδότησης (αναλυτική επίλυση του προβλήματος, γενικότερες υποδείξεις κ.α.). Ο κατάλογος με τις προτάσεις ανατροφοδότησης και οι καλές πρακτικές του FeeD4Mi παρέχονται για τον καλύτερο σχεδιασμό της ανατροφοδότησης.

Αρχικά, το FeeD4Mi εφαρμόστηκε σε έντυπη έκδοση (*Εικόνα 3*). Παρόλα αυτά, για να ενισχύσουμε τη δυνατότητα εφαρμογής του FeeD4Mi σε πραγματικά μαθήματα, δημιουργήσαμε ένα σύνολο οδηγιών ψηφιακού σχεδιασμού που στοχεύουν να επιτρέψουν την ενσωμάτωση του FeeD4Mi σε ψηφιακά εργαλεία, έτσι ώστε οι καθηγητές να μπορούν να αυτοματοποιήσουν τη διαδικασία. Σύμφωνα με τις συγκεκριμένες οδηγίες, αναπτύξαμε ένα ψηφιακό εργαλείο, το e-FeeD4Mi που υλοποίησε το FeeD4Mi συμπεριλαμβανομένης της διαδικασίας, των καταλόγων και των προτάσεων του (Εικόνα 4). Οι οδηγίες ψηφιακού σχεδιασμού είναι οι ακόλουθες:

- Το εργαλείο να μπορεί να αναπαριστά κάθε διάσταση του FeeD4Mi μέσω διαδοχικών οθονών.
- Το εργαλείο να μπορεί να καταδεικνύει στο χρήστη το στάδιο στο οποίο βρίσκεται ανά πάσα στιγμή κατά τη διάρκεια της διαδικασίας.
- Το εργαλείο να μπορεί να αναπαραστήσει ψηφιακά το μάθημα και τα χαρακτηριστικά του.
- Το εργαλείο να μπορεί να περιγράψει τους δείκτες που αναφέρονται στα ψηφιακά δεδομένα των μαθητών.
- Το εργαλείο να μπορεί να παρέχει επιλογές για τον καθορισμό του χρόνου της παρέμβασης ανατροφοδότησης.
- Το εργαλείο να μπορεί να παρέχει τους τρεις καταλόγους και τις καλές πρακτικές του FeeD4Mi.
- Το εργαλείο να μπορεί να συμπεριλάβει τη δυνατότητα προσθήκης νέων προβλημάτων και προτάσεων ανατροφοδότησης αν ο διδάσκοντας το επιθυμήσει.
- Το εργαλείο να μπορεί να παρέχει υποδείξεις και επεξηγήσεις για κάθε ενέργεια του χρήστη ώστε να επιτύχουμε την ανεξάρτητη χρήση του.



Εικόνα 3.Έντυπη απεικόνιση του FeeD4Mi.



Εικόνα 4.Ψηφιακή αναπαράσταση του FeeD4Mi μέσω του e-FeeD4Mi.

6. Μελέτες Αξιολόγησης

6.1. Περιγραφή Μελετών

Τέσσερις μελέτες συνέβαλαν στην αξιολόγηση του πλαισίου FeeD4Mi, καθεμία εκπονηθείσα σε διαφορετικά πλαίσια (όπως, εργαστήρια συν-σχεδιασμού με καθηγητές, εφαρμογή σε πραγματικά μαθήματα) και με διαφορετικούς συμμετέχοντες (όπως, καθηγητές, ειδικοί των MOOC, μαθητές). Συγκεκριμένα:

- Η *πρώτη μελέτη* διήρκεσε από τον Φεβρουάριο έως τον Μάιο του 2020 και εξέτασε την πρώιμη εκδοχή του εννοιολογικού πλαισίου, και συγκεκριμένα, την πληρότητα και τη χρησιμότητα των καταλόγων και της διαδικασίας του FeeD4Mi. Κατά την αξιολογική μελέτη

ακολουθήσαμε μια προσέγγιση συν-σχεδιασμού με τρεις καθηγητές δύο διαφορετικών MOOCs (το ένα σχετικό με την Πληροφορική και το άλλο σχετικό με τις πολιτικές σχέσεις Ευρώπης-Ρωσίας).

- Η *δεύτερη μελέτη* διεξήχθη από τον Δεκέμβριο του 2020 έως τον Νοέμβριο του 2021 και αποτέλεσε την εφαρμογή της πλήρης εκδοχής του FeeD4Mi σε έναν ολόκληρο κύκλο ενός μαθήματος (δηλαδή, από τον σχεδιασμό μέχρι την ολοκλήρωση του μαθήματος). Το MOOC επιλέχθηκε σκόπιμα, καθώς ο καθηγητής διέθετε ένα εργαλείο LA που μας επέτρεψε να εξετάσουμε την εφαρμογή των αυτόματων και ημιαυτόματων παρεμβάσεων ανατροφοδότησης που δημιουργήθηκαν με το FeeD4Mi σε μια πραγματική περίπτωση μαθήματος. Οι συμμετέχοντες της αξιολόγησης ήταν ο καθηγητής του MOOC, ένας προγραμματιστής και οι μαθητές.
- Η *τρίτη μελέτη* πραγματοποιήθηκε τον Ιούλιο του 2021 στο πλαίσιο ενός 3ωρου εργαστηρίου με 11 συμμετέχοντες (καθηγητές, ερευνητές, μαθητές των MOOC). Η επιλογή των συμμετεχόντων βασίστηκε στη διαθεσιμότητα των ενδιαφερομένων και στην εμπειρία τους με τα MOOCs (Fraenkel et al., 2012). Κατά την τρίτη μελέτη χρησιμοποιήσαμε το FeeD4Mi ενσωματωμένο στο ψηφιακό εργαλείο e-FeeD4Mi και αξιολογήσαμε τα χαρακτηριστικά και τις λειτουργίες του εργαλείου και του πλαισίου συγκεντρώνοντας τις αντιλήψεις των συμμετεχόντων.
- Η *τέταρτη μελέτη* διήρκησε από τον Ιανουάριο έως τον Φεβρουάριο του 2022. Η αξιολόγηση αφορούσε μια διαδικτυακή πειραματική συνεδρία με 6 καθηγητές (μια συνεδρία για κάθε καθηγητή) από διαφορετικά εκπαιδευτικά ιδρύματα και με διδακτική εμπειρία σε διαφορετικά γνωστικά αντικείμενα στα MOOC. Οι καθηγητές χρησιμοποίησαν την τελική εκδοχή του πλαισίου FeeD4Mi μέσω του e-FeeD4Mi. Η κάθε συνεδρία διήρκησε 1:30 ώρα.

Το ακόλουθο ερευνητικό ερώτημα κατεύθυνε τις μελέτες αξιολόγησης: «***Πώς μπορεί το FeeD4Mi να υποστηρίξει τους καθηγητές στο σχεδιασμό και την παροχή εξατομικευμένης ανατροφοδότησης βάσει των LA σε MOOC***;». Για επιτύχουμε μια πιο ολιστική απάντηση του ερευνητικού ερωτήματος εξετάσαμε τα ακόλουθα θέματα σε κάθε μελέτη αξιολόγησης: (α) την πληρότητα των τριών καταλόγων, (β) τη χρησιμότητα της προτεινόμενης διαδικασίας, των καταλόγων και των «καλών πρακτικών» του FeeD4Mi, (γ) το αντίκτυπο της ανατροφοδότησης σε καθηγητές και μαθητές, (δ) τον επιπρόσθετο φόρτο εργασίας της χρήσης του πλαισίου και (ε) την χρηστικότητα στη διαχείριση του τεχνολογικού εργαλείου e-FeeD4Mi.

6.2. Αποτελέσματα Αξιολόγησης

Τα στοιχεία που συγκεντρώθηκαν από τα πέντε θέματα επέτρεψαν να απαντηθεί η γενική ερώτηση των αξιολογήσεων. Τα αποτελέσματα που σημειώθηκαν μας οδήγησαν να επιβεβαιώσουμε ότι το FeeD4Mi μέσω των καταλόγων, της διαδικασίας και του συνόλου προτάσεών του δίνει τη δυνατότητα στους καθηγητές: (α) να αποσαφηνίσουν τον σχεδιασμό των μαθημάτων τους, (β) να εντοπίσουν προβλήματα μαθητών σύμφωνα με το μάθημά τους, (γ) να ανιχνεύσουν συμπεριφορές μαθητών, με βάση τα ψηφιακά δεδομένα τους, που μπορούν να προσανατολίσουν τους καθηγητές σε μαθητές που αντιμετωπίζουν κάποιο πρόβλημα, (δ) να επιλέξουν στοχευμένες παρεμβάσεις λαμβάνοντας υπόψη το χρόνο ανατροφοδότησης και (ε) να δημιουργήσουν συνδέσεις μεταξύ των προβλημάτων των μαθητών, των ψηφιακών τους δεδομένων και των προτάσεων αντιμετώπισης των συγκεκριμένων προβλημάτων.

Συγκεκριμένα, τα δεδομένα που συγκεντρώθηκαν αποκάλυψαν ότι το FeeD4Mi μπορεί να εκφράσει τις περισσότερες από τις στρατηγικές ανατροφοδότησης. Ομοίως, όλες οι μελέτες αποκάλυψαν νέα πιθανά προβλήματα μαθητών, δείκτες και προτάσεις ανατροφοδότησης που προστέθηκαν στον κατάλογο στις επόμενες εκδοχές FeeD4Mi. Για παράδειγμα, κάθε μελέτη οδήγησε στην ανάγκη για συμπερίληψης περαιτέρω προβλημάτων σχετικά με τον τύπο του μαθήματος. Σχετικά με τη χρησιμότητα του FeeD4Mi, τα στοιχεία έδειξαν ότι οι κατάλογοι υποστήριξαν τους καθηγητές στον αναστοχασμό και σχεδιασμό των προτάσεων ανατροφοδότησης. Μάλιστα, ακόμη και σε περιπτώσεις που οι καθηγητές έκριναν ότι κάποια προβλήματα μαθητών δεν μπορούσαν να εντοπιστούν, μετά τη χρήση του FeeD4Mi επανεξέτασαν δείκτες που θα μπορούσαν να βοηθήσουν στον εντοπισμό τέτοιων προβλημάτων. Ωστόσο, παρατηρήσαμε πως η συμπερίληψη ορισμένων παραδειγμάτων και περαιτέρω υποδείξεων απαιτείται για να υποστηρίξει καλύτερα τη διαδικασία σχεδιασμού ανατροφοδότησης. Αναφορικά με τον αντίκτυπο του FeeD4Mi σε αυθεντικά περιβάλλοντα, η δεύτερη μελέτη μας έδωσε αρχικές ιδέες σχετικά με τις αντιλήψεις των μαθητών για τη ληφθείσα ανατροφοδότηση, οι οποίες θα πρέπει να συμπληρωθούν με περαιτέρω μελέτες. Συγκεκριμένα, οι μαθητές επιβεβαίωσαν πως αντιμετώπιζαν το πρόβλημα που θεωρήθηκε μέσω των δεικτών που επιλέχτηκαν με το FeeD4Mi. Ο καθηγητής, από την πλευρά του, υπογράμμισε τη δυνατότητα διατήρησης της αλληλεπίδρασης με τους μαθητές μέσω του FeeD4Mi και της αυτοματοποίησης της παροχής ανατροφοδότησης, αποφεύγοντας με αυτόν τον τρόπο πιθανές αποχωρήσεις από το μάθημα.

Στοιχεία συγκεντρώθηκαν και σχετικά με τη χρηστικότητα του e-FeeD4Mi. Συγκεκριμένα, στις πρώτες δυο μελέτες όπου η χρήση του

εννοιολογικού πλαισίου έγινε με έντυπη μορφή, οι συμμετέχοντες θεώρησαν ότι η διαδικασία ήταν χρονοβόρα και πολύπλοκη. Με την χρήση του e-FeeD4Mi στην τέταρτη μελέτη, οι συμμετέχοντες μπόρεσαν να σχεδιάσουν στρατηγικές ανατροφοδότησης σύμφωνα με το μάθημά τους σε διάστημα 40 λεπτών και χρησιμοποιώντας το εργαλείο για πρώτη φορά. Η ικανοποίηση των συμμετεχόντων εκφράστηκε δηλώνοντας τον εύκολα διαχειρίσιμο χαρακτήρα της διαδικασίας. Ο φόρτος εργασίας θεωρείται ως μία από τις πιο κρίσιμες παραμέτρους για τους καθηγητές στην εφαρμογή ή την αποφυγή εργαλείων στις διδακτικές τους πρακτικές (Dagnino et al., 2018). Συνεπώς τα θετικά αποτελέσματα με τη χρήση του τεχνολογικού εργαλείου για τη διαχείριση του εννοιολογικού πλαισίου υποδεικνύουν την πιθανή υιοθέτηση του FeeD4Mi. Επιπλέον, οι δύο τελευταίες μελέτες εξέτασαν την χρηστικότητα του εργαλείου e-FeeD4Mi. Οι γενικές αντιλήψεις ήταν θετικές και αφορούσαν την υποστήριξη που προσφέρει στους καθηγητές για την αυτοματοποίηση των αποφάσεών τους και την ευχάριστη διεπαφή του. Συμπερασματικά, η ενσωμάτωση του FeeD4Mi στο e-FeeD4Mi, χάρη στις οδηγίες σχεδιασμού, αυτοματοποίησε και κατέστησε έγκαιρα προσιτή τη διαδικασία σχεδιασμού εξατομικευμένης ανατροφοδότησης σε MOOCs.

7. Συμπεράσματα

Συνοπτικά, αυτή η διατριβή αντιμετώπισε το ζήτημα της υποστήριξης των καθηγητών στο σχεδιασμό και την παροχή εξατομικευμένης ανατροφοδότησης βάσει των LA σε περιβάλλοντα μάθησης MOOC. Για να ικανοποιήσουμε τον σκοπό της διατριβής: (1) εκπονήσαμε μια συστηματική βιβλιογραφική ανασκόπηση των εργαλείων που χρησιμοποιούνται από καθηγητές στα MOOC για την παροχή ανατροφοδότησης, (2) αναπτύξαμε το εννοιολογικό πλαίσιο FeeD4Mi για να υποστηρίξουμε τους καθηγητές στο σχεδιασμό εξατομικευμένης ανατροφοδότησης, (3) δημιουργήσαμε ένα σύνολο οδηγιών για την ενσωμάτωση του εννοιολογικού πλαισίου σε τεχνολογικά εργαλεία ώστε να αυτοματοποιηθεί η χρήση του πλαισίου.

Σύμφωνα με τον επαναλαμβανόμενο χαρακτήρα της μεθοδολογίας *Έρευνα Βασισμένη στη Σχεδίαση*, πραγματοποιήσαμε τέσσερις μελέτες αξιολόγησης (βλ. Ενότητα 6) που βοήθησαν να ελέγξουμε την χρησιμότητα και χρηστικότητα του εννοιολογικού πλαισίου και του συνόλου των οδηγιών μέσω της ανάπτυξης ενός τεχνολογικού εργαλείου e-FeeD4Mi. Με αυτόν τον τρόπο, ικανοποιήσαμε τον γενικό σκοπό της τρέχουσας διατριβής να παρέχοντας εννοιολογικά και τεχνολογικά εργαλεία, ανάλογα με τις ανάγκες των καθηγητών MOOC (Topali, Ortega-Arranz, Martínez-Monés, & Villagrá-Sobrino, 2021), ώστε να είναι σε θέση να ανιχνεύουν μαθητές που πιθανώς αντιμετωπίζουν προβλήματα και να παρέχουν στοχευμένη ανατροδοφότηση. Αξίζει να αναφερθεί ότι εκτός από την παροχή ανατροφοδότησης σε μαθητές

που αντιμετωπίζουν προβλήματα, όπως αρχικά προβλεπόταν, το FeeD4Mi μέσω του e-FeeD4Mi υποστήριξε επίσης το σχεδιασμό παρεμβάσεων '*θετικής*' ανατροφοδότησης, ως επιβράβευσης, σε μαθητές που ικανοποίησαν προβλεπόμενους στόχους κατά τη διάρκεια του μαθήματος. Αντίστοιχα, τα αποτελέσματα της αξιολόγησης επεσήμαναν περιορισμούς των προτάσεών μας και περαιτέρω ερευνητικές γραμμές που θα ερευνηθούν δυνητικά στο μέλλον.

Κατά την εκπόνηση της συγκεκριμένης διατριβής συναντήθηκαν πρακτικοί περιορισμοί που σχετίζονται με τη χαμηλή διαθεσιμότητα και την έλλειψη πρόσβασης σε MOOC. Λαμβάνοντας υπόψη ότι το ενδιαφέρον της παρούσας διατριβής πλαισιώνεται στα MOOC, η χαμηλή διαθεσιμότητα των μαθημάτων εμπόδισε την εκτεταμένη ανάλυση και αξιολόγηση των προτάσεών μας, πέραν της δεύτερης μελέτης αξιολόγησης. Η διεξαγωγή περαιτέρω μελετών αξιολόγησης σε αυθεντικά πλαίσια θα επέτρεπε την καλύτερη κατανόηση των αδυναμιών του FeeD4Mi στην πράξη και τη βελτίωσή τους. Μια άλλη πρόκληση που αντιμετωπίσαμε σε αυτήν τη διατριβή αφορούσε τη διαθεσιμότητα ψηφιακών δεδομένων των μαθητών από τις διαφορετικές πλατφόρμες MOOC. Πράγματι, αντιμετωπίσαμε προβλήματα στην πρόσβαση των δεδομένων των μαθητών και, συνεπώς, στη δημιουργία των κανόνων ανατροφοδότησης. Τέλος, ένας επιπλέον περιορισμός της τρέχουσας διατριβής σχετίζεται με την αξιολόγηση του εννοιολογικού πλαισίου που δεν μπορεί να υποστηρίξει γενικεύσιμα αποτελέσματα. Στην πραγματικότητα, δεδομένης της ερευνητικής μας προσέγγισης, στοχεύαμε στην βαθιά κατανόηση του θέματος και των βασικών απαιτήσεων και επιθυμιών των συμμετεχόντων αντί της γενίκευσης.

Οι προκλήσεις που συζητούνται παρακάτω θα μπορούσαν να ενημερώσουν μελλοντικές ερευνητικές μελέτες σχετικά με την ανατροφοδότηση βάσει των LA σε περιβάλλοντα MOOC. Όπως αναφέρθηκε προηγουμένως, ως μελλοντική ερευνητική μελέτη προβλέπεται η εφαρμογή του FeeD4Mi σε πραγματικές περιπτώσεις MOOC και η καταγραφή της εμπειρίας των μαθητών σχετικά με τις παρεχόμενες παρεμβάσεις ανατροφοδότησης (για παράδειγμα, εάν είναι ικανοποιημένοι από την παρεχόμενη ανατροφοδότηση) με συστηματικό τρόπο. Επιπροσθέτως, προηγούμενες μελέτες εξέτασαν πως οι διαφορετικοί στόχοι και ικανότητες των μαθητών επηρεάζουν τη διαδικασία μάθησης (Fincham, Gašević, Jovanović, & Pardo, 2019; Jovanović, Gašević , Dawson, Pardo, & Mirriahi, 2017; Prins et al., 2008). Μια πιθανή ερευνητική γραμμή θα μπορούσε να αφορά την εξερεύνηση των διαφόρων τακτικών, μαθησιακών στόχων ή ικανοτήτων κατά τη διάρκεια ενός MOOC για την παροχή εξατομικευμένης ανατροφοδότησης σε διαφορετικές ομάδες μαθητών. Επιπλέον, κατά τη διάρκεια της τέταρτης

μελέτης αξιολόγησης, δύο καθηγητές εκδήλωσαν ενδιαφέρον να χρησιμοποιήσουν το FeeD4Mi όχι μόνο στα MOOC τους, αλλά και στα μαθήματα τριτοβάθμιας εκπαίδευσης που διδάσκουν. Ως αποτέλεσμα, αποβλέπουμε να διερευνήσουμε τη χρησιμότητα του FeeD4Mi στην τριτοβάθμια εκπαίδευση και σε υβριδικά πλαίσια μάθησης. Μια τέτοια συνθήκη θα απαιτούσε εκ των προτέρων κατανόηση του νέου εκπαιδευτικού περιβάλλοντος και των περιορισμών τους (για παράδειγμα, τα προβλήματα των μαθητών τριτοβάθμιας εκπαίδευσης) για να προσαρμοστούν οι και οι κατάλογοι του εννοιολογικού πλαισίου αντιστοίχως.

Appendix B

APPENDIX B: SYSTEMATIC LITERATURE REVIEW PAPERS

This Appendix includes the list of papers included in the systematic literature review, presented in Chapter 4. This table summarizes the bibliographic data related to the authors, title, published year, and venue of the paper.

B.1. The retrieved papers included in the systematic literature review along with their key properties.

ID	Authors & Year	Title	Venue
1	Almeda et al. (2018)	Comparing the factors that predict completion and grades among for-credit and open/MOOC students in online learning	journal
2	Caballe et al. (2014)	A Methodological Approach to Provide Effective Web-based Training by using Collaborative Learning and Social Networks	conference
3	Cobos & Soberón (2020)	A proposal for monitoring the intervention strategy on the learning of MOOC learners	conference
4	Cobos and Ruiz -Garcia (2020)	Improving learner engagement in MOOCs using a learning intervention system: A research study in engineering education	journal
5	Crossley et al. (2017)	Predicting success in massive open online courses (MOOCs) using cohesion network analysis	conference
6	Du et al. (2018)	ELBA: Exceptional learning behaviour analysis	conference
7	Eradze & Tammets (2017)	Learning analytics in MOOCs: EMMA case	book chapter
8	Ezen-Can et al. (2015)	Unsupervised modelling for understanding MOOC discussion forums: A learning analytics approach	conference
9	Ferschke et al. (2015)	Fostering discussion across communication media in massive open online courses	conference
10	Frick et al. (2022)	Analysis of patterns in time for evaluating effectiveness of first principles of instruction	journal

11	Klusener & Fortenbacher (2015)	Predicting students' success based on forum activities in MOOCs	conference
12	Konert et al. (2016)	PeerLA - Assistant for individual learning goals and self-regulation competency improvement in online learning scenarios	conference
13	Lafifi et al. (2020)	Intelligent Tutoring of Learners In E-Learning Systems and Massive Open Online Courses	book chapter
14	Lan et al. (2015)	Mathematical language processing: Automatic grading and feedback for open response mathematical questions	conference
15	Lee et al. (2021)	Prediction of Student Performance in Massive Open Online Courses Using Deep Learning System Based on Learning Behaviours	journal
16	Li et al. (2022)	MOOC learners' time-investment patterns and temporal-learning characteristics	journal
17	Malekian et al. (2020)	Prediction of students' assessment readiness in online learning environments: The sequence matters	conference
18	Meku Fotso et al. (2020)	Algorithms for the Development of Deep Learning Models for Classification and Prediction of behaviour in MOOCs	conference
19	Reza et al. (2021)	The MOOClet Framework: Unifying Experimentation, Dynamic Improvement, and Personalisation in Online Courses	conference
20	Rohloff et al. (2019)	Student Perception of a Learner Dashboard in MOOCs to Encourage Self-Regulated Learning	conference
21	Ruipérez-Valiente et al. (2017)	Scaling to Massiveness with ANALYSE: A Learning Analytics Tool for Open edX	journal
22	Ruipérez-Valiente et al. (2017)	Evaluation of a learning analytics application for Open EdX Platform	journal
23	Ruiz et al. (2014)	Towards the development of a learning analytics extension in open edX	conference
24	Sharma et al. (2016)	A Gaze-based learning analytics model: In-Video visual feedback to improve learner's attention in MOOCs	conference
25	Sharma et al. (2020)	Eye-tracking and artificial intelligence to enhance motivation and learning	journal
26	Singelmann et al. (2019)	Design and Development of a Machine Learning Tool for an Innovation-Based Learning MOOC	conference
27	Smith (2015)	Output from statistical predictive models as input to e-learning dashboards	journal
28	Tegos et al. (2021)	Towards a Learning Analytics Dashboard for Collaborative Conversational Agent Activities	conference

		in MOOCs	
29	Teusner et al. (2018)	Effects of Automated Interventions in Programming Assignments: Evidence from a Field Experiment	conference
30	Thankachan (2017)	Adaptive Learning	conference
31	Tomar et al. (2017)	Coordinating collaborative chat in massive open online courses	conference
32	van den Beemt et al. (2018)	Do instrumentation tools capture self-regulated learning?	conference
33	Vinker & Rubinstein (2022)	Mining Code Submissions to Elucidate Disengagement in a Computer Science MOOC	journal
34	Wang et al. (2017)	Data-driven feedback generator for online programming courses	conference
35	Xing and Du (2018)	Temporal predication of dropouts in MOOCs: Reaching the low hanging fruit through stacking generalisation	journal
36	Xing et al. (2016)	Dropout Prediction in MOOCs: Using Deep Learning for Personalised Intervention	journal
37	Karaoğlan-Yılmaz et al. (2021)	Students' Preferences and Views about Learning in a Smart MOOC Integrated with Intelligent Tutoring	conference
38	Yu et al. (2021)	Adopting software product lines to implement an efficient learning analytics framework in MOOCs	journal

Appendix C

APPENDIX C: FEED4MI CATALOGUES

This Appendix includes the catalogues of learner problems, problem indicators and feedback reactions presented in Chapter 5. For the identification of the different aspects, we followed: (1) a literature review of learner problems, indicators, and feedback theories, (2) exploratory experiences with MOOC learners and instructors, described in Chapter 3; and (3) several evaluations performed with MOOC instructors (see Chapter 6).

C.1. Catalogue of Learners' Problems together with the studies that informed it.

Problems Categories	Problems	References that informed this catalogue
Content Understanding	Content Understanding	Aldowah et al. (2020) Eriksson et al. (2017) Gütl et al. (2014) Henderikx et al. (2017) Kizilcec & Halawa (2015) Nawrot & Doucet (2014) Onah et al. (2014a) [Exp_1] [Exp_3]
Previous Background *Issues related with the previous level of knowledge of the learners*	Activities too difficult Activities too easy	Aldowah et al. (2020) Eriksson et al. (2017) Gütl et al. (2014) Henderikx et al. (2017) Kizilcec & Halawa (2015) Nawrot & Doucet (2014) Saphiro et al. (2017) Onah et al. (2014a) [Exp_1] [Exp_3] [EV_1]
Regulation *A learner has problems affecting their regulation in their learning*	Deadline Issues Self-regulation Issues	Eriksson et al. (2017) Henderikx et al. (2017) Henderikx et al. (2018) Khalil & Ebner (2014) Kizilcec & Halawa (2015) Nawrot & Doucet (2014) Saphiro et al. (2017)

		[Exp_1] [Exp_3]
Peer/Group Collaboration *Issues related with the peer/group collaboration*	"Ghost" members (i.e., absent- non active members)	Nawrot & Doucet (2014) [Exp_1] [Exp_3] [EV_3]
	Unequal contributions to activities	
	Easy/ Tough graders	
Feedback *Issues related to the provision of feedback*	Lack of instant feedback	Aldowah et al. (2020) Cole & Timmerman,(2015) Gütl et al. (2014) Henderikx et al. (2017) Henderikx et al. (2018) Onah et al. (2014a) [Exp_3]
	Lack of useful feedback (e.g., in peer reviews)	
Community Building *Issues regarding the feeling of community-belonging*	Lack of social interaction/Feeling of Isolation	Aldowah et al. (2020) Gütl et al. (2014) Henderikx et al. (2017) Henderikx et al. (2018) Khalil & Ebner (2014) [EV_1]
Technical Problems *Issues related with technical aspects of the course and the skills of the participants*	External links that do not work	Henderikx et al. (2017) Henderikx et al. (2018) [Exp_1] [Exp_3]
	Platform Problems	
	Technical-related skills	
Learning Design (LD) *Issues related with the LD of the course*	Learning Path	Nawrot & Doucet (2014) [Exp_3] [EV_1]
	Critical Points/Milestones	

C.2 Catalogue of Feedback Reactions together with the studies that informed it.

Feedback Focus	Description of Feedback Aim	Feedback Intervention	References that informed this catalogue
Self	Reactions related to praising the learner	Praising messages	Hattie & Timperley (2007) Savvidou (2018)
Task	Reactions relating to how well a task has been accomplished	Messages about correct/wrong answers	Hattie & Timperley (2007) Savvidou (2018)
		Gamification (i.e., badges)	Krath et al. (2021)
Process	Reactions related to the processes needed to perform a task	LD adjustments *(i.e., extend deadline, extra attempts, allow to skip, re-open activity, pass with lower score)*	[EV_2] [EV_3]
		Hints/Cues	Frick et al. (2022) Shute (2008) Wood & Wood (1996) Systematic Literature Review [#CON_1]
		Online informative tutoring/ Guest Speakers	Gregori et al. (2018) Kasch et al. (2017) Savvidou (2018) Shute (2008) Wood & Wood (1996)
		Positive/Negative Exemplars	Nicol & Macfarlane (2006) Systematic Literature Review [#CON_1] [EV_3]
		Commonly asked questions/ Rubrics/Guides	[Exp_1] [EV_1] [EV_3]
		Provision of additional material	Systematic Literature Review [#CON_1]
		Re-assign peer/group member	[Exp_1]
		Mentoring/Connect with other learners	Kasch et al. (2017)
		Discussion prompts, Targeted forums	Kasch et al. (2017) [Exp_1] [Exp_3]
Self-Regulation	Reactions related to self-monitoring and self-direction	Gamification (i.e., leaderboards)	Krath et al. (2021) Ogunyemi (2022)
		Provision of performance statistics *(compared with other learners)*	Biggs & Tang (2007) Savvidou (2018)

	Systematic Literature Review [#CON_1] [EV_2]
Provision of performance statistics *(compared with instructor expectations)*	Biggs & Tang (2007) Savvidou (2018) [EV_2]
Predefined message to (re)visit content material	Gregori et al. (2018) Shute (2008) [EV_2]
Personalised Motivational messages	Dart & Spratt (2020) Hattie & Timperley (2007) Hatziapostolou & Paraskakis (2010) Savvidou (2018) Systematic Literature Review [#CON_1]
Reminders	Systematic Literature Review [#CON_1] [Exp_1]

Appendix D

APPENDIX D: EVALUATION QUESTIONNAIRES

This Appendix presents a general template of the questionnaires applied during the four evaluative studies (see Chapter 6) to gather the perceptions of the MOOC instructors regarding FeeD4Mi. The questionnaire is focused on the different topics explored during the evaluative studies, presented in Figure 6.6. Given that this is a template questionnaire, some of the questions were added, excluded, or adapted to construct the questionnaire finally used in each study. As a result, not all questions are relevant for all evaluative studies.

Dear participant,

We would like to first thank your participation in this evaluation. Before starting, we want to inform you about some important aspects of the evaluation (e.g., goal of this research, participant rights, evaluation tasks).

This evaluation is framed into the PhD dissertation of Paraskevi Topali, which aims to support instructors in the provision of feedback interventions in MOOC environments. Specifically, the goal of this evaluation is to collect the perceptions and opinions of MOOC instructors regarding the main contribution of this dissertation, that is a conceptual framework (named Feedback for MOOC Instructors -FeeD4Mi-) to facilitate the instructors in the design and delivery of the feedback strategies.

The data gathered in this evaluation (questionnaires and interview answers, video and audio recordings, pictures, observations and created design artifacts) will be used with the only purpose of research by the University of Valladolid (anonymized data may be shared with other institutions for research purposes). This data will be stored and processed in devices and servers owned by the University of Valladolid and/or by the PhD candidate. Participants have the right of editing and removing partial, or the full personal data gathered at any time by contacting the PhD candidate (*evi.topali@gsic.uva.es*). The data gathered may be used anonymously for publication purposes. Keep in mind that this is a voluntary participation, and you have the right to cancel the participation in this evaluation at any time without giving any reason.

The evaluation is expected to last 2 hours. Throughout this evaluation, you will be requested to: *(1)* fill out a profiling questionnaire to contextualize your background; *(2)* answer questions regarding the feedback strategies instructors use to apply during their course run-time; *(3)* reflect and create feedback interventions based on your MOOC design using the FeeD4Mi framework and FeeD4Mi tool; and *(4)* fill out a set of questionnaires and participate in a semi-structured interview to collect information about your experience with the framework and the tool.

This is a formative evaluation. Any comment, positive or negative, will be equally valuable. If you have any question during the evaluation, please do not hesitate to ask the researcher.

Again, thank you for participating in this evaluation!

I have read and understood the above information and have received answers to all my questions regarding this study. I agree to participate.

Location and Date:

Name / Signature of participant

Name / Signature of researcher

Paraskevi Topali

Evaluation Worksheet

The purpose of this document is to inform you about some important aspects of the evaluation (e.g., goal of this research, participant role, evaluation tasks).

Purpose of Evaluation

The goal of this evaluation is to collect your experience and perceptions as MOOC instructor regarding the main contribution of my dissertation, that is a conceptual framework (named FeeD4Mi) that facilitates instructors the design and delivery of feedback in MOOCs.

The partial evaluation objectives are:

- to evaluate the degree of guidance FeeD4Mi offers for the design of feedback strategies
- to evaluate the extent to which FeeD4Mi catalogues and recommendations are informative for the design of feedback strategies
- to evaluate the degree the FeeD4Mi covers the feedback aspects mentioned by you
- to evaluate the usability of the tool we will use to put the framework in practice.

Your role in this evaluation

During this evaluation you will act as MOOC instructor who has to design semi-automated feedback supported by FeeD4Mi. While conducting the evaluation tasks described below, we will observe your actions, we will ask you to spontaneously report everything that goes through your mind while doing a task (i.e., think aloud) and we will conduct a short interview at the beginning and at the end of the evaluation session.

Outline of the tasks

The evaluation is expected to last approximately 2 hours. The evaluation process consists of three phases. Concretely:

— ***First Phase***: During this first phase, you will be asked to fill out a profiling questionnaire to contextualize your background and answer questions regarding the feedback you use to apply during your course run-time; *(estimated time 10-15').*

- ***Second Phase:*** During the second phase, you are requested to reflect and create feedback interventions based on the MOOC design you provided us. To do so, you will use the FeeD4Mi framework and the tool; *(estimated time: 75').*
- ***Third Phase:*** During the third phase, you will fill out a set of questionnaires and participate in a semi-structured interview sharing your insights about your experience with the framework *(estimated time: 30').*

The data we will gather in this evaluation regard questionnaires and interview answers, video and audio recordings, pictures, observations and created design artifacts.

Before the FeeD4Mi use

Profiling Questionnaire

1. What is your educational background (i.e., topic of experience)?
2. How many years do you teach at the University?
3. Which has been your role regarding MOOCs up to now?
4. Which have been your responsibilities (e.g., preparing content, facilitating the learners, other)?
5. What is your previous experience as MOOC instructor, teacher, or instructional designer:
    a. 0 courses
    b. 1-2 courses
    c. 3-4 courses
    d. 5+ courses
6. In which platforms have you delivered courses?
7. In which topics have you delivered courses?

Catalogue Completeness

8. Do you use to provide feedback to support the learning experience of the MOOC learners (e.g., learners who are disengaged with the course)?
    8.1. If yes,
        8.1.1. what kind of feedback do you provide/did you provide (e.g., sending motivational messages to learners)? *[Open Ended]*
        8.1.2. Do you use to dedicate time to design feedback interventions before the course enactment or do you provide feedback on-the-fly (e.g., do you provide feedback when a learner asks for help?)? *[Open Ended]*
        8.1.3. How much time do you spent for providing feedback? *[Open Ended]*
        8.1.4. Do you use specific tools to support you during the feedback provision? *[Open Ended]*
        8.1.5. Are there typical moments that you do provide feedback (e.g., Do you provide feedback when a learner asks for help? Do you observe learners' progress and accordingly you provide feedback?)? *[Open Ended]*
    8.2. If no, why? *[Open Ended]*

After the FeeD4Mi use

FeeD4Mi Usefulness

9. Did the reflection on Learning Design help you to carry out the design of the feedback strategies? *[Open Ended]*
10. What other aspects apart from difficulty, optionality of the activities, highlighting milestones would you consider as relevant for the design of feedback strategies? *[Open Ended]*
11. Did FeeD4Mi suggested you with problems that you did not consider before and which were useful in the design of feedback of your course? Please specify your answer *[Open Ended]*
12. Did FeeD4Mi suggested you with indicators that you did not consider before and which were useful in the design of feedback of your course?? Please specify your answer *[Open Ended]*
13. Did FeeD4Mi suggested you with feedback reactions that you did not consider before and which were useful in in the design of feedback of your course? Please specify *[Open Ended]*
14. To what extent the FeeD4Mi process helped you to shape feedback targeted to concrete problems? *[Open Ended]*
15. To what extent did you find the recommendations (i.e., proposals of indicators and proposals of feedback reactions for each problem) informative? Specify your answer *[Open Ended]*
16. How did you perceive the FeeD4Mi process followed (i.e., identification of LD components, identification of problems, identification of indicators and thresholds, selection of reactions) for the design of targeted feedback strategies? *[Open Ended]*

Catalogue Completeness

17. Is there something in FeeD4Mi (either in problems or indicators or feedback reactions) that you would like to have, and you missed? *[Open Ended]*

Feedback Impact on Instructors & Learners

Questions for MOOC Instructors:

18. Did you find the rule-based information created with FeeD4Mi useful? What was the most useful? *[Open Ended]*
19. Did you find the rule-based information created with FeeD4Mi interesting? *[Open Ended]*
20. What did you like the most and what did you like the least? (From experience? From implementing the rules? From the process?) *[Open Ended]*
21. What would you change? (About the process that we design the rules, the experience when using the tool, managing student problems in real time, etc?) *[Open Ended]*
22. After all the experience, would you apply the same problems, indicators and feedback reactions? *[Open Ended]*

Questions for MOOC Learners:

23. We have detected that *[indicator]* and *[indicator]* is [*more/less]* than the one we have expected. We think that you may face difficulties with [*learners' problem*]. Is that so? *[Open Ended]*
24. In case you face a problem, but it is not the indicated one, please let us know what kind of problem you are experiencing. *[Open Ended]*

FeeD4Mi Workload

25. How hard did you have to work to accomplish what you were asked for? *[Open Ended]*
26. Did you find the FeeD4Mi process in terms of effort and time worthy to spent? *[Open Ended]*

After the e-FeeD4Mi use

e-FeeD4Mi Usability

This is a standard questionnaire that aims to explore your experience with e-FeeD4Mi. Please, answer the following questions providing as more details as possible in your answers[20]. To measure e-FeeD4Mi usability we employed the SUS

27. I think I would like to use e-FeeD4Mi frequently.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
28. I found e-FeeD4Mi unnecessarily complex.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
29. I thought e-FeeD4Mi was easy to use.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
30. I think that I would need the support of a technical person to be able to use e-FeeD4Mi.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
31. I found the various functions in e-FeeD4Mi well integrated.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
32. I thought there was too much inconsistency in e-FeeD4Mi.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
33. I would imagine that most people would learn to use e-FeeD4Mi very quickly.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
34. I found e-FeeD4Mi very awkward to use.
    Strongly Disagree 0 1 2 3 4 5 Strongly Agree
35. I felt very confident using e-FeeD4Mi.

[20] This questionnaire is based on the standardised instrument *System Usability Scale* (SUS)(Brooke, 2013)

Strongly Disagree 0 1 2 3 4 5 Strongly Agree

36. I needed to learn a lot of things before I could get going with e-FeeD4Mi.
Strongly Disagree 0 1 2 3 4 5 Strongly Agree

37. How likely are you to recommend e-FeeD4Mi to others for providing feedback in MOOCs?
Not at all likely 0 1 2 3 4 5 6 7 8 9 10 Extremely likely

Questions for Reflection

38. Please mention three things you like the most. *[Open Ended]*
39. Please mention three things you like the least. *[Open Ended]*

Appendix E

APPENDIX E: ABBREVIATIONS

This Appendix introduces a list of all the abbreviations, acronyms and labels often used throughout this dissertation. The following table contains its significance.

E.1. Abbreviations, acronyms, and labels used throughout this dissertation.

Abbreviation	Significance
[Art]	Artefacts
CON_*n*	Thesis Contribution *n*
DBR	Design-Based Research
[Diary]	Weekly Diary
e-FeeD4Mi	The tool that implements the 'Feedback Design for MOOC Instructors' Framework
[Exp_*n*]	Exploratory Study *n*
[EV_*n*]	Evaluative Study *n*
HCLA	Human-Centre Learning Analytics
FeeD4Mi	The 'Feedback Design for MOOC Instructors' Framework
IQ	Thesis Informative Question
[Int]	Interviews
LA	Learning Analytics
LD	Learning Design
[Log]	Activity Logs
MOOC	Massive Open Online Course
OBJ_*n*	Thesis Objective *n*
[Obs]	Observations
[Post_Quest]	Post Questionnaire

[Rec]	Recordings
RQ	Thesis Research Question
T*n*	Topic *n* (associated with the Research Question)

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