





Construction of personalized learning pathways through mixed methods

Construcción de itinerarios personalizados de aprendizaje mediante métodos mixtos

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ABSTRACT

This paper deals with the implementation of personal learning pathways in a technology-enriched environment to enhance learning experiences in initial teacher training. The study uses mixed-methods within a design-based research approach. In a first phase of the approach, the characteristics that personalised learning pathways should meet were identified. In the next stage, the learning sequences' structure for the pathways was designed, considering context, teaching-learning approach, tasks and assessment. The main result is an interchangeable learning sequence structure prototype that enables the configuration of personalised learning pathways by the students themselves, and the exchange and co-design of learning pathways between different teachers. The students select the sequences from a catalogue, organising their own learning pathways from the combination of different types of sequences offered. This strategy promotes students' autonomy and self-direction in the learning process, as well as their development of personal information management and collaborative work skills. The conclusion is that the proposed personalized pathways present an adequate balance between the structure, result of the learning design and / or co-design, and the necessary autonomy for the self-direction of their own learning process, whether in individual learning or in the collaborative construction of knowledge.

RESUMEN

Este trabajo se ocupa de la aplicación de itinerarios personales de aprendizaje en un ambiente enriquecido por tecnología para la mejora de las experiencias de aprendizaje en la formación inicial docente. Se utiliza un enfoque mixto aplicando investigación basada en diseño, para identificar las características que deben reunir los itinerarios personalizados de aprendizaje y diseñar la estructura de secuencias didácticas que configuran dichos itinerarios atendiendo al contexto, al enfoque de enseñanza y aprendizaje, a las tareas y a la evaluación. El principal resultado es un prototipo de estructura intercambiable de secuencia didáctica que permite la configuración de itinerarios personalizados de aprendizaje por parte de los propios estudiantes, al mismo tiempo que el intercambio y co-diseño de itinerarios entre distintos docentes. Los estudiantes seleccionan las secuencias de entre un catálogo de ellas, organizando sus propios itinerarios de aprendizaje a partir de la combinación de diferentes tipos de secuencias ofertadas, promoviendo la autonomía y autodirección del proceso de aprendizaje y el desarrollo de competencias de gestión personal de la información y de trabajo colaborativo por parte de los alumnos. Se concluye que los itinerarios personalizados propuestos presentan un adecuado equilibrio entre la estructura, fruto de la labor de diseño y/o co-diseño didáctico, y la autonomía necesaria para la autodirección del propio proceso de aprendizaje, ya sea en aprendizajes individuales o en la construcción colaborativa del conocimiento.

KEYWORDS | PALABRAS CLAVE

Learning sequences, curricular design, learning pathways, personalised learning environment, didactic strategies, self-regulated learning, design-based research, digital.

Secuencias de aprendizaje, diseño curricular, itinerario de aprendizaje, entorno personal de aprendizaje, estrategias didácticas, aprendizaje autorregulado, investigación basada en diseño, digital.



1. Introduction and state of the art

One of the most commonly reiterated central ideas with regard to learning design is that students are active agents, which places them at the heart of the teaching-learning process. However, for this to happen, it must be noted that one of the keys to achieving learning goals lies in the autonomous management of a skill set that contributes to such an achievement. This is a set of transferable skills that are usually related to the concept of self-regulated learning or academic agency. Most importantly, it is the student who is in control of his or her own learning process.

In this context, a key element in the application of digital technologies in the teaching-learning process is the flexibility of the design. This flexibility should characterize the objectives, strategies, learning sequences and assessment methods, both formal and informal. All of these elements are closely linked to the idea of flexible learning, student-centred teaching, and learning approaches. (Adams-Becker et al., 2017; Gros & Noguera, 2013; Sharples et al., 2016). It is a question of adapting learning pathways and sequences to the individual student by promoting generic competencies for the management and transmission of knowledge, as well as autonomy and responsibility in learning processes, based on self-regulation or “agency”. This is a concept that refers to the ability to act intentionally, and thus to achieve a purpose or goal, guided by the cognitive, self-regulatory, motivational and attributional factors that enable students to actively contribute to their own learning (Castañeda et al., 2014; Jääskelä et al., 2017; Jääskelä et al., 2020).

Increased autonomy, context affinity and greater interdependency in terms of agency provide enhanced interaction and the opportunity for the shared control of learning activities via intercommunication within a supportive and collaborative framework (Delfino & Persico, 2007; Sharples et al., 2016). In this sense, we need to look at the evolution of personalised learning environments (PLE) as one of the key processes in knowledge management systems in the field of learning (Castañeda & Adell, 2013; Marín et al., 2014; Tur et al., 2016). Personalised learning pathways are applied right from the point where teachers approach a subject from the perspective of course design, which is itself underpinned by the concept of personalised learning pathways. In effect, from the moment the student becomes involved, either through co-design or in terms of the configuration of some of the elements, s/he is effectively taking the design proposed by the professor and using it as a springboard for the construction of her or his own personalised learning pathway. A pathway is understood to comprise one or more learning sequences, with students being able to navigate through these different sequences.

The concept of a sequence of learning was initially developed by Taba in 1962. For this author, it was “a way of organising content, as well as a sequence of the reactions, behaviours and demands of learning”. Both content and learning experiences must be staged appropriately in order to facilitate active comprehension” (Taba, 1974: 386). This concept has also been termed “didactic sequence”, (Díaz-Barriga, 1997; Tobón et al., 2010). For these two authors “didactic sequences are simply articulated sets of learning and assessment activities that, through the mediation of a professor, seek to achieve certain educational goals, taking into account available resources” (Tobón et al., 2010: 20). In the context of this research, a learning sequence is a proposal for activities to be included in a teaching-learning cycle within a comprehensive structure, to be undertaken by both professors and students in order to create experiences that lead to meaningful learning.

On the other hand, a learning pathway is understood as a structure that acts as an organiser of both the concepts, themes, etc., to be learned, and the learning objects to be utilised, thus providing a full picture of what needs to be done in order to understand a particular subject, or to develop a particular competence. A flexible navigation system provides options or alternatives that can be followed when constructing personal learning sequence(s). In this case, navigation is adjusted in line with individual characteristics (needs, learning style, previous learning experiences, motivation, degree of autonomy, etc.), and when the control over these learning sequence(s) is passed to the student, we speak of flexible learning (Cañas & Novak, 2010; De-Benito et al., 2012). Therefore, a pathway can include one or more learning sequences. For De-Benito et al. (2012) a flexible learning pathway is characterised by:

- Being an organiser of concepts, topics to be learned, competences to be developed.
- Being an organiser of the learning objects to be utilised.
- Giving a comprehensive overview of what needs to be done in order to understand the topic in

- question.
- Offering options or alternatives to follow in the construction of each student's own learning sequence based on individual characteristics and needs.
 - Making use of what is known as an expert map.

The aim is always to generate proposals for methodological strategies that respond to different approaches to teaching in virtual environments (Goodyear & Dimitriadis, 2013), both in relation to the representation of knowledge through learning materials delivered in different ways, and to the procedures for designing and producing those materials (Conole, 2013; Hernández-Leo et al., 2018; Laurillard, 2012; Marcelo et al., 2016). This is based on elaboration theory in terms of the importance of strengthening the initiative and student responsibility for the construction of their own learning (Reigeluth, 1999) and of making that learning meaningful (Ausubel et al., 1983; Novak, 1998).

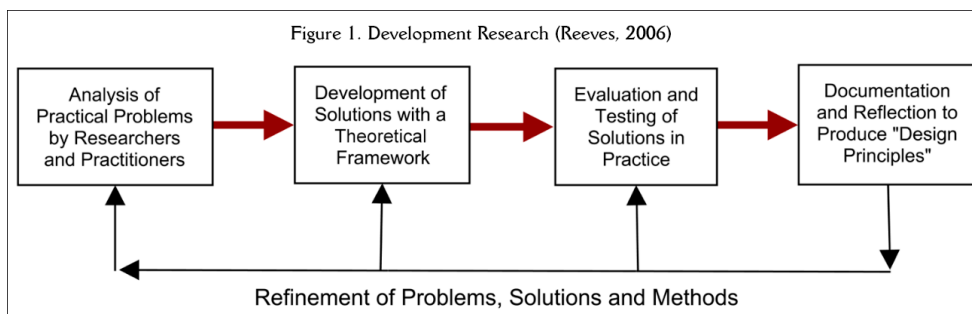
The proposal presented in this paper has been developed on the basis of design-based research (DBR), understood as an emerging paradigm/methodology in educational research that constitutes a problem-oriented research framework and generally uses mixed methods (Creswell, 2014; Creswell & Plano Clark, 2018). This type of research has always been associated with technology and innovation in education (Wang & Hannafin, 2005), particularly as it evolved among researchers who were creating technology-enhanced learning environments.

The objective of the study is to design a methodological proposal based on the construction of personalised learning pathways from a set of learning sequences offered to students and aimed at fostering student autonomy and responsibility within the teaching-learning process. It is about designing and validating didactic sequences for the construction of personalised learning pathways, identifying how the methodological proposal promotes student self-regulation and validating the use of concept maps as a tool for the representation of learning pathways. These objectives are aimed at answering the following question: What are the characteristics of learning sequences that contribute to the construction of personalised learning pathways, which promote student autonomy and responsibility within the teaching-learning process?

2. Material and methods

During the project, a methodological approach rooted in design-based research has been applied, since it concerns the improvement of educational design processes, and how they are developed and evaluated, geared towards resolving both specific and highly contextualised problems and generalised research procedures (Richey & Klein, 2014).

One of the key attributes of DBR is that it takes place in a real educational setting, validating the research and enabling the results to be used effectively to evaluate, inform, and improve practice not only within that setting, but potentially in others as well (Anderson & Shattuck, 2012).



To achieve this, possible solutions are designed based on a theoretical framework of reference and the participation of stakeholders, in this case researchers and professors in education studies. This research follows the model developed by Reeves (2006), as represented in Figure 1, in which he proposes an iterative process consisting of four phases: the collaborative analysis of problems, the development of solutions, iterative cycles of assessment and fine tuning, and finally reflection and implementation of the

improved solution. In this paper, we are particularly concerned with the various improvement cycles that focus on developing solutions (didactic sequences, personalised pathways).

For Easterday et al. (2014) design-based research is a process that integrates design and scientific methods to enable researchers to generate useful outcomes, and an effective theory for resolving both individual and collective problems in education. Therefore, it is a question of thinking of education and educational technology as a science with a strong design component, emphasising its interdisciplinary and problem-solving approach. Design-based research is a valid methodological option that is being used increasingly often. This new approach arises from the need to put research findings into practice, and to incorporate them into the development of theory, focusing on the resolution of practical problems.

Consequently, this type of study takes place within a problem-oriented research framework and would fit into what Creswell (2014) defines as multi-phase mixed method research. This research involves the implementation of programmes in which several phases of the project are spread out over time and where the different types of methods used are mutually reinforcing when addressing a common program objective. In fact, most of the literature on design-based research agrees that the mixed methods approach is appropriate for the collection and analysis of data generated by this type of research project because it is able to maximise validity and increase the objectivity and reliability of ongoing research (Alghamdi & Li, 2013). Zheng (2015), in a review of the literature on design-based research published between 2004 and 2013, found that although qualitative methods were most frequently used, the use of mixed methods was growing (28.21%).

DBR and mixed methods share many of the characteristics that Teddie and Tashakkori (2010) propose for mixed methods, particularly in the sphere of education (Christ, 2010). One of these, the pragmatic approach, allows design-based researchers to be methodologically creative (McKenney & Reeves, 2012); but as with mixed methods, a pragmatic perspective should not be confused with ill-defined positions where everything is considered to be valid (Design-Based Research Collective, 2003): 6). In comparison with more positivist research paradigms, DBR is much closer to a vein of real-world pragmatism, where the problem/research question determines the methodology (Creswell, 2014; Creswell & Plano Clark, 2018).

As a result, design-based research takes an eclectic approach on the design and implementation of research methods by drawing on all research designs (preferably mixed methods) depending on the immediate need within the DBR study, assuming that each form of data collection provides a different type of information (open data in the case of qualitative data and closed data in the case of quantitative data) (Creswell & Creswell, 2018). This combination or integration of different methods results in a pooling of strengths or an offsetting of weaknesses if the aim of the research is for each to complement the findings of the other (Christ, 2010).

Table 1. Sources of information and data collection techniques

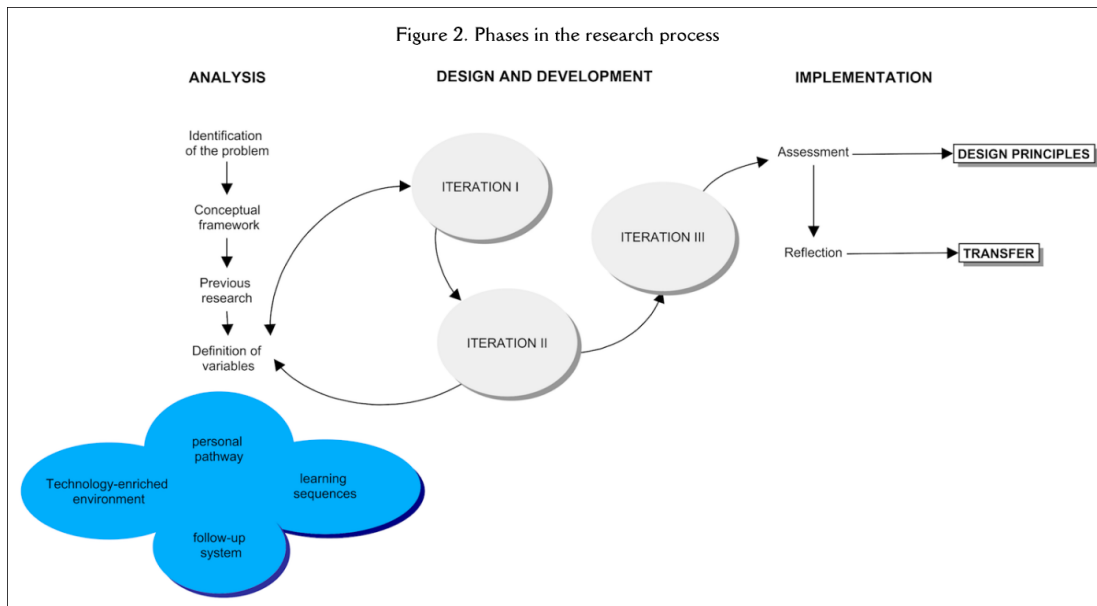
Variables	Data collection techniques
Didactic sequences	Nominal groups Student opinion questionnaire Seminars given by experts
Learning pathways and self-regulation	Student opinion questionnaire End of activity student feedback form Nominal groups
Technological environment	Initial questionnaire on technology use Student opinion questionnaire Nominal groups Activity log Teacher observation journal
Conceptual maps (representation of personalised learning pathway)	Interviews with students Map assessment via rubric
Follow-up and monitoring	Discussion groups with experts Student opinion questionnaire Nominal groups

The research presented here addresses the design and testing of learning sequences that are integrated into different undergraduate subjects to facilitate the construction of personalised pathways. Together with the design of the structure that these sequences must follow, a study is made of the implications of

the integration of personal environments in terms of teaching and managing (e.g., student-tutor, student-student design and co-design). These sequences are placed in a catalogue in order to support the transfer and collaborative construction of learning, and self-regulation.

As described by Creswell (2014) in his definition of mixed multiphase methods, throughout the process there is a shift from quantitative to qualitative studies, and above all to a combination of the two, which are mutually reinforcing in addressing a common project objective. In this case, we have an exploratory sequential design, QUAL->QUAN, in the typology used by Creswell and Plano Clark (2018), which primarily seeks to generalise the findings of the qualitative study. A variety of sources of information and data collection techniques have been used in this research study, as is the case in the DBR. These techniques are presented in Table 1.

Using the framework developed by Reeves (2006) represented in Figure 1, the research carried out has been structured in different phases as shown in Figure 2 below.



- Phase 1. Analysis.

The first phase corresponds to the identification of the problem and the conceptual definition of each of the central elements or variables within the methodological strategy to be developed. These first two steps were developed based on a review of the documentation (design principles) and an analysis of earlier research carried out by the research group.

The objective in this first phase was an approach to the object of study involving the application of quantitative data collection techniques via the systematic review of research related to the variables, and qualitative techniques via “future workshops” led by experts aimed at the clarification of the nature of the problem and the definition of concepts, following nominal group technique.

- Phase 2. Design and development of methodological proposals.

This phase involved the design and development of the methodological strategy, and each of the iterative cycles that allow it to be readjusted and fine-tuned. Each iterative cycle was linked to the collection of quantitative and qualitative data based on the study variables: a) Personalised learning pathways; b) Didactic sequences; c) Technological configurations; d) Follow-up system and self-regulation.

With regard to the construction of personalised learning pathways, concept maps were used as a tool for students to represent these, using different data collection techniques. On the one hand, qualitative techniques via interviews aimed at obtaining valuable information from students regarding the creation and representation process of their personalised learning pathways were used. On the other hand, concept map analysis techniques were employed by adapting the rubric developed by Prats (2016) together

with student perceptions as expressed in end-of-course questionnaires. The design and validation of the structure of the learning sequences has been approached in two ways, through the “collaborative analysis of practical problems by researchers and participants”, and via the “development of solutions based on design principles and technological innovations” as proposed by Reeves (2006).

These have each been addressed separately at seminars in the “future seminars” format, involving a group discussion forum to brainstorm future solutions to current problems: “Self-regulation and the flexibilisation of the Teaching-Learning process” and “Flexible learning pathways”. The first was focused on reflection and decision making regarding the conceptual framework to be worked in relation to self-regulation, agency and the flexibilisation of the teaching-learning process. It included the monitoring and tutoring system aimed at the personalisation of learning pathways. The second was an international seminar aimed at reflection and decision making with regard to the structural aspects of the project related to the design of flexible pathways and their components.

A decision was made to use an adaptation of the nominal group technique for both seminars, since they involved identifying problems, generating solutions and making decisions (Miranda, 2017; Varga-Atkins et al., 2017). The data obtained was used in the generation of the first personalised learning pathways prototype. Once this prototype had been implemented, a questionnaire was administered that included items specifically related to the factsheets corresponding to each sequence.

In addition to the personalised learning pathways, the design of the technological configuration supporting them has adapted the methodological proposal to the institutional platform, which is the digital classroom. Student perceptions were obtained by means of a questionnaire, a nominal group with the teachers involved in the experience, and by looking at the different tools utilised based on information gathered from the system’s activity log and the teacher observation diaries.

In the development of the monitoring system designed to support the implementation of personalised learning pathways, the opportunities that the institutional platform has to offer are being studied and adapted, extrapolating the results of earlier research. This system has been validated by means of record sheets, teacher interviews and nominal groups (with the participation of experts and teachers).

- Phase 3. Assessment and reflection.

The final iterative cycle corresponds to the development of the definitive prototype of the methodological strategy, its implementation and assessment. As in the previous phase, quantitative and qualitative data collection and analysis techniques were applied by looking at student opinion questionnaires, the analysis of personalised learning pathways, activity logs and incidents in the technological environment, as well as interviews with students and teachers.

- Phase 4. Documentation and generation of design principles.

This phase is concerned with documentation completion and preparation. It includes the description of the methodological proposal, dissemination via networks, conferences, meetings, publications, etc., and activities to enable the transfer of the proposal to different contexts.

3. Analysis and results

In this section, the results obtained from the first version shown in Figure 2 are presented in relation to the construction of didactic sequences and their use in the creation of personalised learning pathways.

3.1. Definition and types of didactic sequence

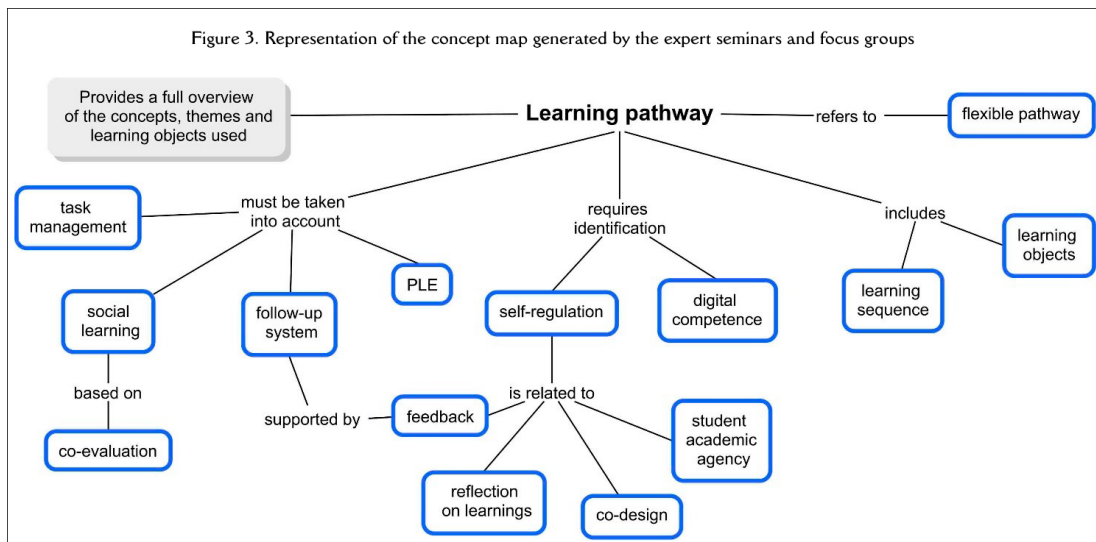
At the seminars mentioned above, the structure, types of sequence and factsheets containing information on each of the sequences were designed using the nominal group technique involving experts and teachers.

The nominal groups were made up of nine teachers of educational technology at the undergraduate level in the social education, early childhood education, primary education and pedagogy fields. In addition, two seminars were held with experts in order to define, and to delve into the project’s key concepts. In the sessions with experts, different concepts such as personalised learning emerged, and there was a review of the associated concepts used over the last 60 years.

Related to this is technology-based adaptive learning, which has much in common with flexible or personalised pathways. Figure 3 shows the concept map and the connections that emerged from the seminars with the experts previously mentioned, and those that are considered key to the research are highlighted. A larger version of the map can be accessed at <https://bit.ly/35zbWQM>.

From the information collected through the nominal groups, a working proposal has been developed to generate these pathways made up of compulsory sequences, sequences where the student is offered alternatives from which s/he needs to choose, and others that may be purely optional (which are not compulsory).

These sequences have different levels of granularity, and depending on the activity, the student group and the teaching method, five types of sequences are proposed in an exploratory way: conferences/exhibitions, workshops, projects, seminars and other sequences that can get the student actively involved with problem-solving tools such as guided research, discussion or debate with an expert, searching, locating and evaluating digital resources, etc. (De-Benito et al., 2020).

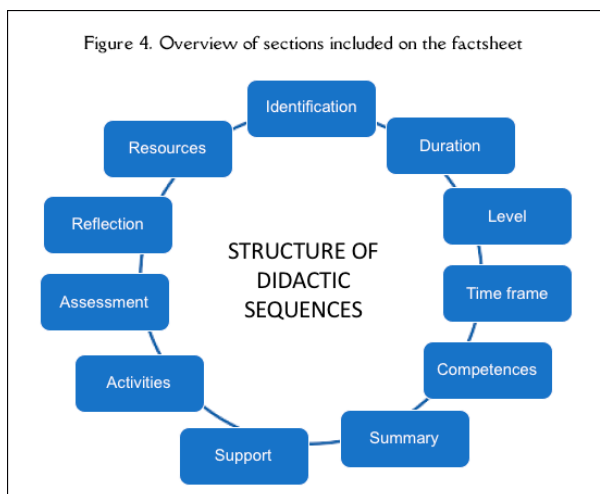


Another important aspect in the construction of flexible pathways is the need for a monitoring and assessment system that favours both the management of learning sequences, and student support and assessment. From the map, it is clear that this flexibility implies the use of technology enriched environments that on the one hand require self-regulation strategies that favour student academic agency, and on the other hand, need sufficient digital competence to be able to set up a personalised learning environment.

3.2. Creation of a repository of didactic sequences

Another research outcome has been the creation of a repository of learning sequences aimed at the transfer and collaborative construction of learning, while promoting self-regulation from the perspective of agency.

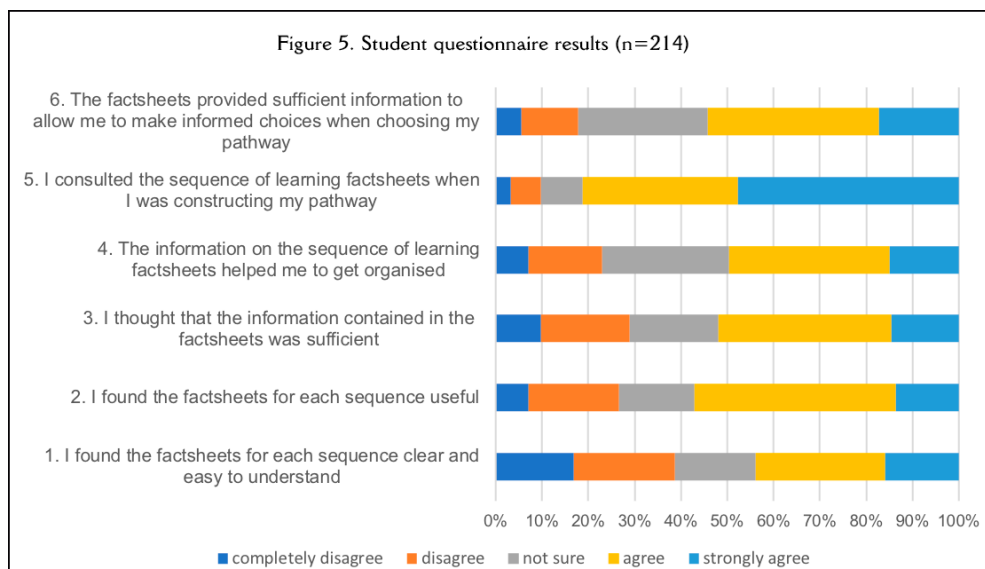
To achieve this, the elements proposed by Conole (2013) were taken into account: context, teaching and learning approach, tasks and assessment. Based on the results obtained from the nominal groups, a factsheet was designed for each sequence, in order to facilitate selection during the process of constructing personalised learning pathways, as well as exchange between the teachers in charge of different subjects (De-Benito et al., 2020), as shown in Figure 4. During the 2019-2020 academic year, around 70 teaching sequences of the different types described in 3.1 have been created.



3.3. Student assessment of factsheets

Once the first prototype was launched, the opinions of the students participating were collected via a questionnaire on the information provided in the sequence sheets, asking them how useful they had found these when choosing their own pathways.

Figure 5 shows the results obtained and indicates that the vast majority consulted the factsheets when constructing a learning pathway. In relation to the information provided, around 50% thought that it was sufficient for them to be able to make informed choices when selecting the sequences that would make up their own pathways, and that it helped them to organise themselves and had been useful. To a lesser degree, they found the factsheets easy to understand.



3.4. Integration of results

The process of designing the sequences constituted the first version of the DBR project and was based on a review of the literature and of previous research along with the development of "future seminars", as described in 3.1. The validation of factsheets for each sequence had to be carried out taking the different variables into account and using different techniques and instruments for collecting information within the general framework of the study (Table 1).

The results of the student opinion questionnaire show that almost 80% of students said that they consulted the factsheets when constructing their pathway. However, the answers to other questions related to the quantity, clarity and usefulness of the information contained on the factsheets indicate that improvement is required here. In addition to formal aspects, it is considered fundamentally important to take into account other variables such as how the selection of sequences is organised, the visualisation of the pathway's structure, or the assimilation of the methodological strategy based on the construction of personalised learning pathways by students. These variables are important as this methodology is new, and it is one that they are not accustomed to finding in areas where a more traditional form of teaching is used.

The following versions require, on the one hand, the factsheets to be revised by professors teaching on other courses unrelated to the subject in question, so that the clarity of the information can be assessed, and on the other, an improvement in the way that the methodological strategy underpinning the construction of personalised learning pathways is presented.

4. Discussion and conclusions

This paper describes the research process supported by DBR and the way that this methodological approach uses mixed methods for the data collection and analysis. A methodological proposal has been developed based on the construction of personalised learning itineraries based on the students' selection of the didactic sequences that are to make up their own pathways.

In the case discussed here, the outcomes are the design and development of a catalogue of didactic sequences to be used in the construction of the pathways, and their application in an initial version for the validation of the first prototype.

The results obtained show that the proposed personalised learning pathways present an appropriate balance between the structure (didactic design, didactic strategies, learning pathways and sequences, etc.) that characterises the work of didactic design and/or co-design, along the lines indicated by Conole and Oliver (2007), Conole (2013), Gros and Noguera (2013) and Prendes et al. (2018): on the one hand, the autonomy required for the self-regulation and self-direction of the learning process itself, or between the individual aspects of agency and self-regulation (autonomy, motivation) and on the other, the community, interdependence and collaborative construction of knowledge (Cabero, 2013; Sharples et al. 2016). Specifically, innovative methodological proposals have been incorporated, based on the tools provided by technology-enriched learning environments. Based on these, various skill sets have been developed. Personal information management skills (access, selection, distribution of information) have been encouraged as can be seen in Llorente (2013) and particularly in Marin et al. (2014), and competencies related to the autonomy and self-regulation of the learning process (organisation, motivation, assessment, etc.) (Jääskelä et al., 2020), together with communication and collaborative work competencies (communication between stakeholders through the transfer and collaborative construction of knowledge) along the lines indicated by Dabbagh and English (2015) or Dabbagh and Kisantas (2013).

Additionally, a great deal of information was obtained that has contributed to the redesign of some features of the prototype, and which has been incorporated into the second version that is currently being rolled out (De-Benito et al., 2020). The variety of data collection techniques used ensures that the results obtained can be effectively used to assess, inform and improve the practice in the context of research on personalised learning pathways, and possibly in other similar training contexts.

Hence, the use of DBR implies that the design of the intervention is a collaborative task undertaken by the researchers and professionals taking part. This task begins with an accurate assessment of the educational context and the identification of a problem, in order to be able to propose improvements in practice, as suggested in McKenney and Reeves (2012). In our case, the intervention in question was the testing of didactic sequences integrated into different undergraduate subjects in order to facilitate the construction of personalised pathways, and the professionals involved were university professors.

The present study, like all design-based research, has a practical focus. In this study, we have attempted to find a solution to a real problem in the training of future teaching professionals, and to develop a series of skills that have already been mentioned. However, at the same time, it has generated knowledge about

the characteristics essential to interventions associated with greater control and autonomy for students, as well as other forms of knowledge connected with the processes themselves involved in the design and implementation of personalised learning pathways, and the most appropriate ways to develop effective and feasible interventions underpinned by theory.

Funding Agency

This paper has received support from the Institut de Recerca i Innovació Educativa (the Institute for Educational Research and Innovation) via project (PID192010), Design of a Prototype for the Integration of Personalised Learning Pathways and a Progress Support and Mentoring System, and project (EDU2017-84223-R), Strategies and Methodologies for the Personalisation of Learning Pathways in Technology-Enriched Environments, funded by the FEDER/Ministry of Economy, Industry and Competitiveness/AEI.

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