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Improving pedagogical design in higher education: untangling the learning activity complexity through students' declared performance

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Abstract

Decision processes to improve pedagogical designs have been commonly based on the superficial comparison between learning design and students' results. This article focuses on proposing other ways of analysing the learning experience in higher education by exploring the (1) "participant's declared performance" (PDP) as a collection of complex data, as well as (2) the qualitative visual network analysis (VNA), as a sustainable technique, to be used for untangling the learning activity. For this purpose, a mixed-method naturalistic case study of a pre-service teacher training course in a Spanish university, run by one professor and with the participation of 58 students, is presented. Materials collected included course design documentation regarding tasks and performance roles, students' blog posts and satisfaction questionnaires. Findings demonstrate that the joint analysis of various elements – including PDP and VNA – shows the correspondence between learning design and student's experiences. It also highlights prominent design aspects and weaknesses and provides insights for improving the learning design in future course editions. The reflection on PDP and VNA's use is an opportunity to provide, feasibly and sustainably, qualitative information for educators to research their pedagogical practices.

Keywords: Networked learning, Learning design, Learning activity, Visual network analysis (VNA), Pre-service teacher education

Introduction

Networked learning starts from the premise that learning activity emerges and cannot be designed (De Laat & Dohn, 2019; Networked Learning Editorial Collective (NLEC) et al., 2021). However, an unavoidable responsibility of the teaching role is to evaluate which

activity emerges from the learning design that he/she proposes in a specific learning task to be able to assess it, implement improvements in it, and, if necessary, redefine it globally or in parts (Matuk et al., 2015). Exploring forms of analysis of the students' learning activity to make this evaluation is desirable for improving educational practice (Goodyear & Ellis, 2010).

Analysing how teachers situate the learning activity with their pedagogical design is complicated, but there are ways of approaching it. However, analysing student's learning activity itself is a much more elusive task. On the one hand, students transform the "task" proposed to them by their teachers, translating it into their terms and reconfiguring it (Selander, 2008). Therefore, what students actually do, does not always coincide with what teachers want them to do (Elen, 2020; Goodyear & Ellis, 2010). The learning activity is far from being defined simply in discrete elements or separated contexts; instead, it consistently exceeds the borders of institutional environments and, in any case, takes the shape of embodied sociomateriality by participants (Gourlay, 2021).

Due to the above, many of the studies that aim to analyse a course's performance – or the adequacy of its learning design – almost always, just compare aspects of the design with results or with final satisfaction rates. Lately, especially in higher education, these comparisons have been "enhanced" with discrete data about single aspects of the students' activity generally collected with a specific instrument or – at best – with a repeated measurement (and some learning analytics) (Mangaroska & Giannakos, 2019; Pishtari et al., 2020; Rajabalee et al., 2020). Due to this effort to avoid the complexity, these studies' results assume a black box in developing the learning activity, and their conclusions are aligned with what Biesta (2010) called an input-output vision between pedagogies (way of teaching) and learning results.

This paper explores alternative elements that "reveal" the participant's action to analyse the learning activity. This specific case uses what is called "the students' declared performance", which allows a more complex perspective of the learning activity that happens during a course, which helps to understand better how it does happen. Our ambition is to use this element in the research design, where it configures an elements' set of analysis with the course learning design and the learning results (expressed in terms of student's satisfaction). This use would allow us to abound in more complex decision-making processes that include sociomaterial elements and enrich the future redefinition of these learning designs. In parallel, this paper is testing and proposing ways for analysing this element – the students' declared performance – in a complex but sustainable way through mechanisms such as the visual network analysis (VNA). The research questions of the study are, therefore, connected to these different aims.

Case description

Study context

To achieve the goals of this work, we propose a case study that can create knowledge and understanding about our object of interest – the teaching and learning experience – that allows researchers to capture the different elements that contribute to its complexity (Mills et al., 2009).

The studied experience is an in-campus pre-service teacher training course in a Spanish university titled "Educational Resources and ICT for Primary School". This course is offered in English for students of the first year of the degree in Primary Education during the spring semester, with a complete organisation of 6 ECTS (European Credit Transfer System) and a student workload estimation of 150 hours. The course is run by one professor (female with over ten years of teaching experience in higher education) over 12 weeks (5 hours per week) with no teaching assistants involved.

The studied course edition (2019-2020) was attended by 58 students, 47 women (81%) and 11 men (19%). Students were between 18 and 39 years old ($\sigma = 2.9$).

Research questions

This study explores three questions through a specific case study. Considering the usefulness of the students' declared performance as an alternative element to analyse the learning activity and therefore, to improve course design, the study poses two research questions:

- How does the course's learning design correspond to what participants express/declare to do – the learning activity – during the course experience?
- How could the course's learning design be improved in the following editions to enrich higher education students' learning activity?

In addition, since the study is testing ways of analysing the students' declared performance in parallel, the third research question is related to the technique used with that purpose:

- Is VNA a proper analysis strategy to understand different aspects of the declared performance of the participants clearly?

Method

This study follows a naturalistic, qualitative interpretive approach since it tries to understand the experience as a complex multi-layered reality using its participants Campo as the main data collector (Cohen et al., 2017; Hatch, 2002). Therefore, to answer these

three research questions in a unified analysis, the study explores the learning activity in the course by combining three main perspectives summarised in Figure 1:

- the learning design, which will serve as a guide for analysis,
- the students' declared performance, which is a piece of complex information about the actual learning activity, including the sociomaterial aspects, and
- the students' satisfaction/opinion regarding their course experience understood as the results of the course.

Additionally, it is fascinating to consider the sociomaterial approach as a prominent feature of the analysis. As Fenwick (2016) states, a sociomaterial approach includes a vision of the material (objects and technologies, tasks) and the social (human bodies) "as mutually implicated in bringing forth everyday action and knowledge" (p. 669).

As could be evident from Figure 1, this process pursues a complex thinking approach. It collects not just obtrusive observations and data but also unobtrusive ones (Woodside, 2010), combining at least three strategies to increase the research validity: rich data, triangulation and comparison (Yin, 2010).

Data collection and analysis

Course learning design

The study uses the **learning design documents** as an instrument for unobtrusive data collection (Hatch, 2002). Most documents are already published – in Spanish – in the Professor's teaching statement, and others in the Learning Management System (LMS) as

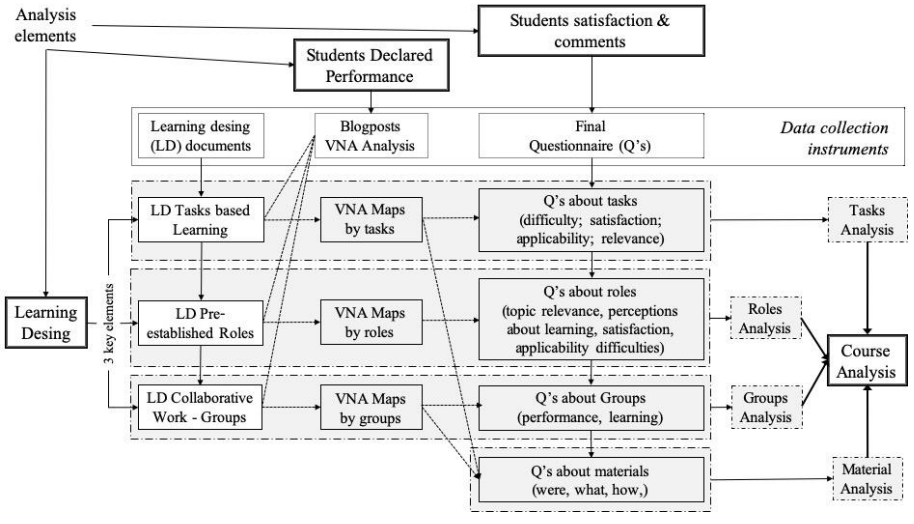


Fig. 1 The methodology of the study

the course's instructions. This data is unobtrusive evidence – they have not been created intentionally for the study (Yin, 2013).

From these documents, we know that the course is designed around three large functioning structures that shape the course environment, not only from the social viewpoint but also from the epistemic[a] one[b]:

- A formal cooperative learning model (Johnson et al., 2014) works under a strategy of cooperative base groups. These are groups whose functioning is long-term, members are heterogeneous, and the composition is permanent (Johnson, 2006). Further description of the specific aspects of the group's development is available in Appendix 1.
- Task-based learning: it consists of a structure of weekly trialogical learning tasks (Paavola & Hakkarainen, 2014). A theoretical topic defines each of these tasks, and students are developing an artefact with a concrete format and under a specific predesigned strategy of development. This strategy must be presented in a particular format during a session that follows a concrete pedagogical strategy. All those elements of each task (detailed for each task in Appendix 2) are contents of the course.
- Pre-established work roles. The course uses work roles as a helpful strategy for reducing passivity among participants and highlighting students' interdependence with their roles (De Wever et al., 2010). The model of pre-established work roles or Scripted Roles (Dillenbourg, 2002) emphasises the tasks and processes designed for the course and making explicit the competencies intended to be developed (Strijbos & Weinberger, 2010). In this case, performed roles were centred on transversal competencies; therefore, the expected role performance is the same in every task, even if the student who performs the role in the group changes every week. The definition of the course roles and the competencies included in each one of them are detailed in Appendix 3.

These functioning structures may help us analyse the learning activity from different perspectives; therefore, we will use them as research data.

The students' declared performance

Students'/participants' declared performance is the way we use to call a complex collection of data that approach researchers to participants' actual activity, which, ideally, includes their reflections about the activity. The best way to collect students' declared performance (SDP, from here on) is not singular and does not come invariably from one specific part of the activity. SDP is an element reached by collecting different data pieces depending on the activity we want to analyse. The declared performance would include the student's voice concerning the learning activity, describing discrete data and being explored in many

ways (i.e., from different types of reflections, various formats, collaboratively with other participants) to get essential information. This part is especially suitable to understand learning as an emergent activity that only surfaces when learners perform their activity (Carvalho & Yeoman, 2019; Goodyear & Carvalho, 2016).

In this case study, every role in each group is to write at least one blog post to explain the role performance and present the task's performance. We have used the content of all those **posts** (N=550) as unobtrusive data collection for exploring the SDP of the course.

To analyse these posts, we have used a VNA strategy based on three views, according to the learning design elements: per role, groups, and tasks. Blog posts per each role, group and task were analysed via text-mining functionality and visualised through constructing maps based on networked data with VOSviewer 1.6.11 (van Eck & Waltman, 2011). The posts were separated into different text data files and used to create co-occurrence maps, where the items (nodes) are terms used in those posts, and the links represent how often two words appear together (distance between things). The higher the weight of an item, as connected to the number and strength of its links, the more prominent it appears on the map. The text data are identified and linked using natural language processing algorithms based on text mining (van Eck & Waltman, 2018). These text-mining algorithms, which identify noun phrases and the selection of the most relevant noun phrases, lead to the process of identification of clusters of items (van Eck & Waltman, 2011).

Clusters may be actants of the activity (e.g., tasks, contents, connections, roles, groups, materials) and are represented with distinct colours. Clusters could include one or more items with solid links, although there is no overlap between clusters in VOSviewer.

To create the different networked maps regarding each actant is crucial to have a set-up of standard procedures. It is helpful to obtain depurated maps that could help identify the relationships between the learning design functioning structures of the course (tasks, contents, connections, roles) and the SDP. Therefore, some terms that did not relate to the actors to be identified were deleted, as well as the terms mentioned in diverse ways were replaced. The network visualisation is one of the three possibilities offered by VOSViewer to represent data. This study selects this visualisation for the co-occurrence maps since it seemed to distinguish better the relationships among the actors in our sociomaterial analysis (networked maps created are available in Appendices 4, 5 and 6).

Students' satisfaction and comments

After finished the course, students were asked to participate in a final online questionnaire. Using scales anonymously, they could show their perception and satisfaction regarding the relevance, difficulty, performance, and satisfaction of the course's main aspects (i.e., tasks, roles, groups) and other performance elements; for example, the material elements and

some metacognitive elements. Questions of the questionnaire and their relationship with the different aspects of analysis are included in Appendix 7.

Material elements

Besides the abovementioned elements, we considered it interesting to add the material perspective to the analysis. Although the last aspect of analysis explicitly understands all the actants of the activity in a sociomaterial way, in this study, we have also expressly explored students' material experience as fundamental actants of the learning activity, especially in higher education (Carvalho et al., 2020). We analyse them by asking students questions about their material experience in the final experience students' questionnaire and through the VNA.

Results

Four sections provide the results of this study, according to the four considered elements in the analysis. Combined, all of them help us to answer the three research questions posed.

First, we present the results regarding the roles played by the students in the course. Then, the second part provides the findings of the course tasks. The third section presents the data about groups, and, finally, the last quarter of the results explains the data about material elements.

Roles

As mentioned, data regarding roles were obtained from the definition of the roles in the learning design prepared by the teacher, the declared performance of the roles through the blog posts and the students' perceptions of the roles (questionnaire) (data collection instruments that have been included in this analysis are presented in Figure 2).

Most roles' declared performance included the teacher's significant features in the design, so this suggests the definition of the roles was well explained and understood by students.

The role Star was perceived as the most important (9.43 out of 10 by average in "Relevance in the group work") and appeared as a node in three of the other roles' networked maps. The Translator and the Facilitators' role performances are connected. The Analyst (valued with an average of 9.17 in the "Relevance in the group work"), Curator (7.29 in average) and Journalist (7.36), were not explicitly included as nodes of relationship in the SDP. Even if those data did not clarify the perceived relevance, they show us the relationship between roles perceived expressly by the students. Besides, it suggests the importance of making the relationships between roles more evident to enrich the cohesion.

The roles perceived as more difficult were the Star (with an average of 8.15 out of 10 in "level of difficulty") and the Analyst (7.81). Nevertheless, the Translator, Journalist and Facilitator's networked maps showed specific clusters dedicated to explaining the role's

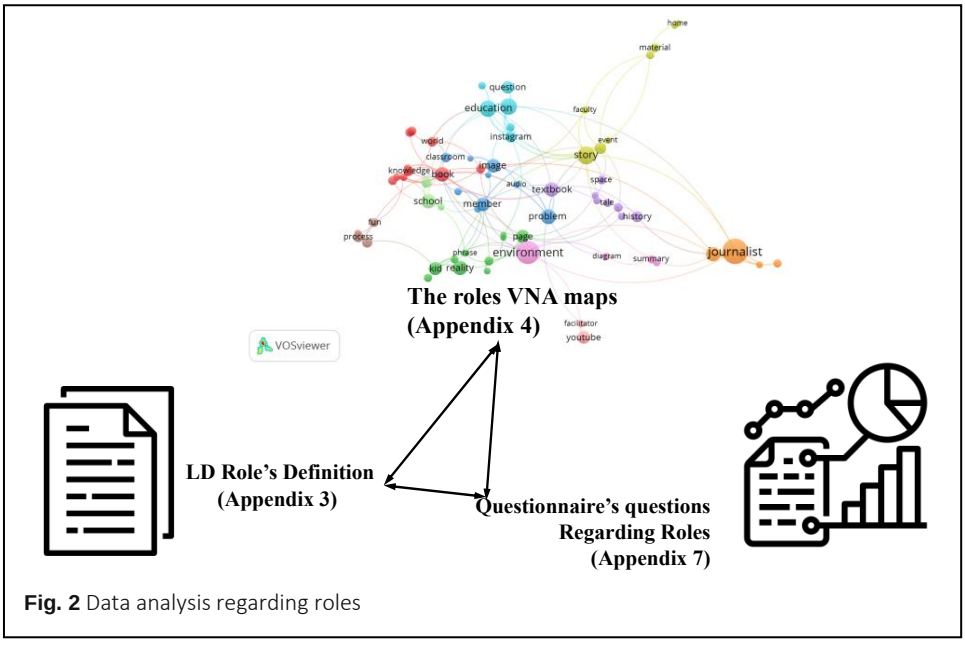


Fig. 2 Data analysis regarding roles

performance, some in a very straightforward way (Journalist and Translator had specific nodes with their role's names). Even if those roles were not those declared as the "most difficult" (Translator is the third more difficult valued with 7.25, but Facilitator with 5.76 and Journalist with 5.72 are considered the easiest), their task was more undefined or needed more explanation, at least when they were reporting the performed job.

Tasks

Data regarding tasks were obtained from the description of the task's features (topic, artefact, strategy for development and presentation, formats) in the learning design by the teacher, the declared performance of the tasks through the blog posts and the students' perceptions of the tasks (questionnaire) (the schema of triangulation is shown in Figure 3).

Most tasks' declared performance comfortably represented the topic and their summary (the activity) described by the teacher in the learning design. Links to roles were present in most of them too. In the first four tasks of the course, the SDP included parts of the artefact format, but the presentation format and strategy were not explicit.

Correspondingly, those tasks' visualisations included many terms related to tools (e.g., technology, app). Students' perceptions about task 1 (Conceptual images) showed it as the least relevant (they valued the task with 7.55 by average out of 10 by relevance) and applicable task to the professional future (7.93 by average in the correspondent item) and the least they learned about ICT and primary education (6.86 by average). Tasks 3 (Comic life) (7.9 out of 10 by average on "how much you like this task") and 4 ("Under Bloom's eyes") (7.60) were the least liked by students.

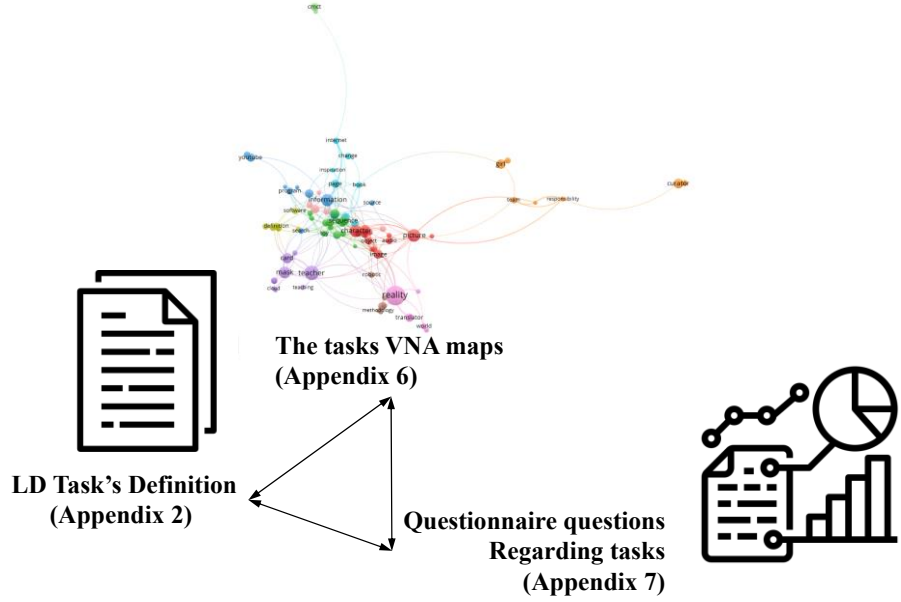


Fig. 3 Data analysis regarding tasks

Task 5, "Fair project", seemed to mark a turning point in SDP. Terms related to technology looked less prominent than other words related to the experience (e.g., reality, process, teacher). Besides, this task was the best perceived of all the students' tasks in terms of liking (9.28 out of 10 by average), feeling its importance (9.05), learning about ICT (9.38) and primary education (9.28), satisfaction with the individual work (9.24) and with the workgroup (9.14) and its applicability to the professional future (9.43).

From task 5 on, the SDP did not concrete the artefact format clearly and focused instead on parts of the presentation strategy (e.g., reflection, exposition, opinion, feedback) and artefact development strategy (e.g., flipped classroom). Task 6 ("My PLE") was the second-best valued in terms of group work satisfaction (9.02 out of 10 as an average) after task 5. At the same time, task 7 ("Other's PLE") (8.71 out of 10), and task 9 (Final portfolio) (8.45 out of 10), received good perceptions regarding learning about ICT. Task 9 was valued positively in learning about primary education (second place with a value of 8.78 by average) and featured terms like reality and future in SDP. Task 8 ("The dark side of textbooks") was perceived as the most satisfactory in terms of individual work (9.03) and applicable to the professional future (9.14), also after task 5.

Groups

Data regarding groups were obtained from the description of the conditions of the groups in the learning design from the teacher, the declared performance of the groups through the blog posts and the students' perceptions of the work in the course – a part referring to group work (questionnaire) (see how information has been triangulated in Figure 4).

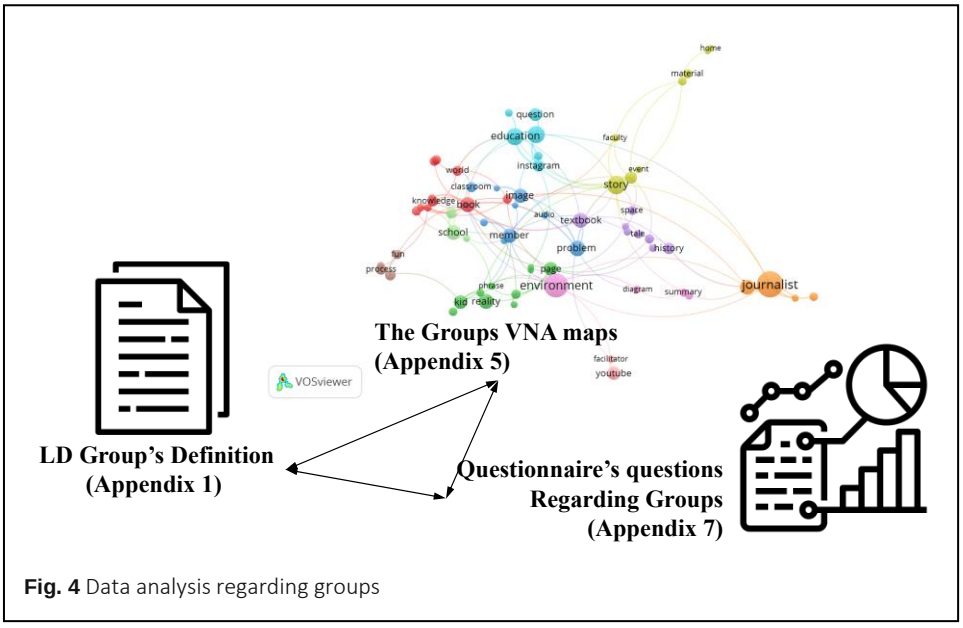


Fig. 4 Data analysis regarding groups

Relations among roles in groups were visible in the groups' declared performance (but also in some tasks). The dynamics of groups (e.g., positive interdependence, work monitoring) as described in the learning design were not always much explicit, but some elements were present. Students' perceptions helped to support this holistic vision.

The groups' declared performance was present in seven groups (out of 9), although one of them did not seem to have completed their group blog; therefore, their data from the declared performance were limited.

In three out of seven groups, the word "teacher" appeared, in two even with the course teacher's name. These groups corresponded to many students in each of them perceiving that the teacher was kind and friendly and cared about the group. There was an exception in another group where no mention to the teacher was present in the group's declared performance. It is worth to remark now that, from the 58 students who answered the question "How do you describe the relationship of your group with the teacher?", 56.9% chose the option "She is kind and friendly, she cares about us", 41.38% chose the option "Correct and polite but distant" and just one student selects the option "She is especially dry with our group, we have the impression to bother her".

In most groups, the group work was present in the SDP through member, team, partner or role. In three groups, the teaching method was part of the SDP through reflection, methodology, debate, feedback, community or classmate. Teaching aspects were also reflected through some students' comments concerning the best parts of the course experience being the cooperative work, working by activities/tasks, working in teams; many also remarked again task 5. Satisfaction with work was more evident where the method was highly valued. As negative aspects, many students perceived the course work

tied to a heavy workload; just a few complained about group work and self-evaluation in groups.

Material elements

Data regarding material aspects were obtained from the declared performance of the tasks and groups through the blog posts and the students' perceptions of the course's material aspects (questionnaire) (see Figure 5).

Most tasks and groups' declared performance included the various tools and devices used in each task, sometimes rather generally (e.g., technology, tool, app, video, internet, picture, photo). However, spaces and reading materials mainly were missing from these declared performances. Exceptions for often referred physical spaces were classroom and school – anecdotally, in task 5 and group 2, "home" appeared. However, "the school" as space appeared in some tasks and groups as a part of the topic addressed but not as the students' working space during the course.

Documentation from the tasks was made visible in the tasks' declared performance through terms such as article, link, material (e.g., in task 7) or document (e.g., task 4), but also in the groups' declared performance (e.g., link, article, publication, website, material, resource, page, source).

The most present tools and devices in the tasks' declared performance included Instagram and YouTube. This result is consistent with the students' appreciation of these tools. For instance, students valued Instagram as one of the prettiest/funniest tools – 55.17% of students declared using it often to make the activity funnier/prettier, and 25.86% declared to do it sometimes – and were present in all tasks except the third. Also, it appeared in four groups' declared performance and as part of the presentation strategy in some tasks. In the

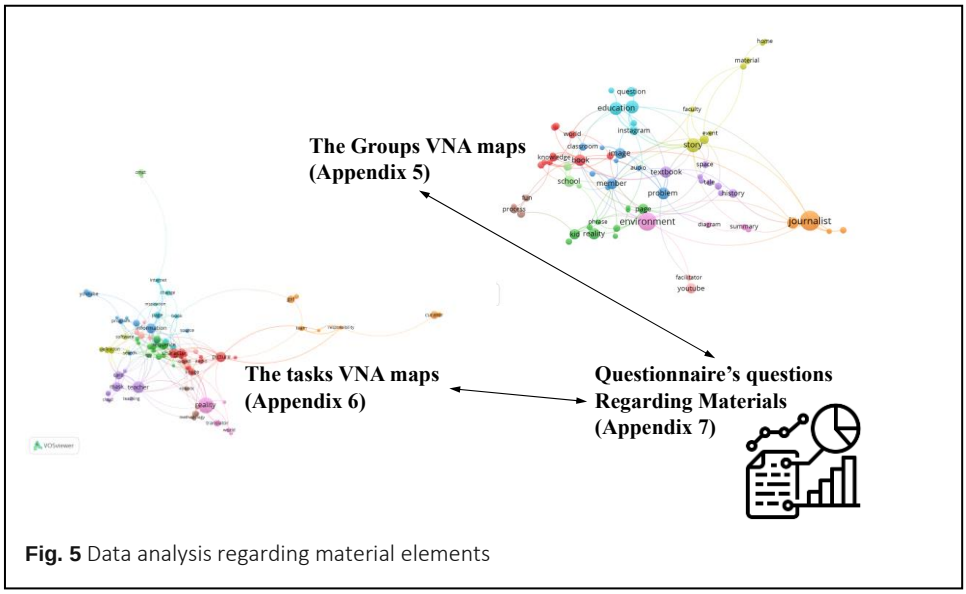


Fig. 5 Data analysis regarding material elements

case of YouTube, it received an average value for being considered pretty/funny (24.14% often considered the tool in this way, and 24.14% sometimes). It was valued at the same time as fundamental as part of the activities by students: 24.14% declared to use it often "as a fundamental part of the activity", and 22.41% declared they do it sometimes. Also, it was present in all tasks' declared performance except task 2, as well as in the declared performance of six groups. Although Twitter was perceived as not applicable by students (50% considered they "could do the task without it"), it appeared in the two tasks' SDP and three groups. Similarly, "paper" as material, and part of the presentation strategy in some tasks, was also perceived as not too helpful – 31.03% of students answered they could do the course activity without using it (paper or notebook), even if 17.24% of students also declared that they print the documents for reading them at home and 46.55% admitted they use paper or notebook to take notes while reading. Nonetheless, paper was present in two tasks and two groups.

The tool Genially and the use of robots were perceived almost as pretty/funny as students' Instagram – 37.93% declared they use it sometimes to make the activity funnier/prettier, and 20.69% they do it often, but its presence in the SDP only accompanied robots in a few tasks and groups. Remarkably, fundamental tools, such as the LMS, email, WhatsApp, Google Drive, mobile phone or the laptop, did not consistently appear in the SDP of tasks, even if students have declared they use those tools as fundamental parts of the activity sometimes (LMS 6.9%, email 24.14%, WhatsApp 8.62%, Google Drive 5.17%, mobile 8.62%, laptop 3.45%) or often (LMS 62.07%, email 44.83%, WhatsApp 62.07%, Google Drive 58.62%, mobile 74.14%, laptop 63.79%). However, some appeared in the SDP of groups. For example, (mobile) phone appeared once in a task and a group; Google Drive in three groups. Other tools appeared in one or two groups, e.g., Dropbox, Flickr, Google Hangouts, blog, Kahoot, Prezi or (mind) maps.

Besides, some material aspects connected to the course topics and tasks, but unrelated to the actual materials that students used, appeared: e.g., computer, iPad or camera.

Discussions and conclusion

In this study, we aimed to understand a course's learning experience as a complex, multi-layered reality through an alternative data collection and sociomaterial analysis. The study contributes to the field by providing evidence-based ways of improving educational practice through reasonable quantitative and qualitative analysis and showing its insights applied to a case study.

The learning experience

We first analysed how this higher education course's learning design corresponded to what we know about students' learning activity; in other words, what students have experienced

and done during the course according to what they expressed/declared. In that sense, and based on the analysis, we can conclude the students followed the learning design to a great degree. The most valued roles and tasks were explicit, as well as some elements of the group work (e.g., intra-group collaboration, task-based work or teacher presence).

However, there were exceptions. One refers specifically to the undefinition of some roles and lack of connections between some of them. Another one concerns parts of the tasks that were not always explicit in the student's instructions (artefact format, development/presentation strategy) and the inter-group collaboration. Although the material aspects were not an evident part of the learning design, their analysis through the SDP and students' satisfaction shows that they were present, especially concerning tools and devices.

Finally, it is also worth mentioning the evolution observed in the students' perception of the learning activity, which was not foreseen in the learning design but it has been evident in their SDP. We could venture a change in the students' perspectives related to the tasks, from a more techno-centric view in which new tools were paramount (the artefact format, but also the topic in terms of tools) and the strategy for artefact development and presentation were blurred (difficult to identify the process), to the learning processes related to the interactions with technology, but also with the group/s (presentation strategy).

Although we can just guess it, the reason behind it may be related to the students' involvement in a significant and authentic activity ("Fair project"). This authentic approach might make students change how they reflected on this task and subsequent tasks by adopting a view focused on the learning process rather than on the product alone.

Improvements for the learning design

The study's conducted analysis and corresponding findings also answer our next question: How could the course's learning design be improved in its following editions to enrich higher education students' experience? One aspect of improvement would refer to the more precise definition of some roles and tasks and the consideration of a higher implication of the inter-group work within the learning design.

The second element of improvement concerns the teacher's presence. Data revealed that students valued the course professor, and her role was central for many. This consideration would be desirable and valuable, given the importance of teacher presence in formal learning contexts (Cleveland-Innes & Wilton, 2018). Nevertheless, if the ultimate goal of a networked learning proposal is empowering students for learning and being prepared to solve diverse challenges (OECD, 2019), it would be interesting to dive further into strategies that step back and allow students to interact, manage and regulate their learning (Czerkawski, 2016) progressively (not in vain they are first-year university students). The pedagogy-andragogy-heutagogy (PAH) continuum may be a functional instructional

theory for designing and developing such strategies, aiming at heutagogy/self-determined learning as a primary purpose (Blaschke, 2012). These strategies could improve students' engagement and reinforce their action for building their Personal Learning Environment (PLE) (Dabbagh & Castañeda, 2020).

The third element of improvement refers to material aspects. Data showed an evident gap related to spaces and technologies, beyond consideration of technologies as instruments. It could be ventured that students may feel these material aspects invisible because they are part of their daily routines. However, results would still support that instructors and designers continue understanding technology as something instrumental and the impact of the students' material conditions in the learning activity keeps being almost hidden. There are no evident considerations in the learning design about the technology's social role, neither about developing critical students' commitments with the technological environment (Facer, 2011; Oliver, 2016).

Spaces and reading materials were often missing from the learning design. This gap leads us to think that it is essential to better-considering material aspects (e.g., in the learning design) to understand students' (work) spaces and conduct further material analyses in higher education. Also, the institutional materials conditions (on-campus such as the classroom organisation and online such as the LMS) were part of the learning design; nevertheless, the students' material conditions for developing the learning activity were hidden and somewhat ignored in the observation of the course. That must be considered in the following editions of this course (Carvalho et al., 2020).

The VNA and the participants' declared performance

The previous observations related to the first two research questions bring us to the third question: is VNA a proper analysis strategy to understand different aspects of the participants' declared performance clearly?

In this respect, Czerkawski (2016, p. 12) remarked the "development of theoretical models, design frameworks or practical guidelines eventually could open up new possibilities for such longitudinal studies". Consequently, we must add the development of sustainable and feasible methodological approaches – and tools – to empirically study the courses that would improve higher education teachers' opportunity for developing action-research-based practices (Cochran-Smith & Lytle, 1999). From this viewpoint, even if it is necessary to create more research that probes its suitability, using VNA as a technique to explore what we call "students' declared performance" would open the opportunity of using semi-automatisation processes to analyse unobtrusive data of our courses. Additionally, those explorations would help to study the course's aspects – even with our students. This opportunity is relevant for at least two reasons.

First, the inclusion of elements to explore the SDP is a way to enlighten the actual learning activity's reality. As said before, the SDP is not a type of data. Still, data that include unobtrusive information that collects the declared participants' experience regarding the course could be shaped by data. This data would be collected only if, in the course design, some participants' explicit reflection would later be used to explore the learning performance as a metacognitive strategy and a course evaluation strategy. We consider VNA to fulfil the SDP expectations by aiding us to see where undefinitions of parts of the learning design from the participants' perspectives (roles, group work, tasks) emerged. Moreover, VNA was also helpful to see the progress of tasks from the students' views.

Second, we convene with other authors to say that although VNA is a qualitative research method (Decuypere, 2020), it is not as reliable as content analysis that could methodologically guarantee the complex vision, validity and strength of a qualitative approach (De Laat & Lally, 2004). Nevertheless, considering most qualitative methods are cumbersome and time-consuming, the content analysis would not be realistically considered a technique to improve online courses in the current higher education structure. Therefore, using a semi-automatised approach, such as VNA, to look into the qualitative data would become a midway tactic to enrich the course evaluation's perspectives using the benefits of automatic analysis (Rajabalee et al., 2020) but avoiding the most simplistic approaches of learning analytics based on clicks. Therefore, it would also take other procedures closer to the social learning analytics proposals (Buckingham Shum et al., 2016; Buckingham-Shum & Ferguson, 2012) and critical learning analytics' approaches (Scott & Nichols, 2017). Therefore, although VNA has been used in rather different settings so far (e.g., see Wang et al., 2017), we argue it could also be applied as a way of learning analytics by providing qualitative information that would help instructors improve their learning designs with a necessary interpretation.

Limitations and future paths

As a limitation of this work, we would like to remark that, despite the coherence between the declared students' work and the learning design is considered acceptable, it also implies the bias of the collecting data sources. Not in vain, we have analysed the students' "declared" performance, and – as its name remarks – this comes from the students' blog posts which they also create to achieve the best possible grades – these posts are part of the elements that the teacher includes in the course's formative assessment.

We would also like to acknowledge the absence of the instructor/designer's perspective, considered an active participant in the learning activity, as a further limitation of the study, which is a similar situation in many studies about Networked Learning (Czerkawski, 2016). It would be desirable to collect the "teacher/instructor's declared performance" to have a

more holistic perspective about the learning activity itself and offer a more comprehensive vision about the learning design. Therefore, we suggest future work may integrate the instructors' view into the complex sociomaterial analysis and, given the findings, consider material aspects for teaching and learning in higher education. Another exciting research line would include exploring heutagogic approaches that foster student agency, in line with the aims of higher education in general.

Additionally, exploring ways to highlight other actants in the learning activity that could still be hidden would be exciting. The proliferation of further studies with complex complementary perspectives would help us realise how to combine the need for sociomaterial complex explorations with scalable research designs that could have a tangible impact on higher education's teaching and learning activities.

Appendix 1. Group characteristics

References: Johnson et al. (1991, 2014)

If we are to characterise the type of approach to cooperative learning that became generalised in the course work, a formal cooperative learning model was chosen (Johnson et al., 2014). This cooperation model theoretically follows a **certain structured time path**, which responds to some previous guidelines from the teacher. In this model, aspects such as the task and the **positive interdependence** are explained by the teacher. The teacher assumes a key role by requesting, **making explicit and analysing the processes of monitoring the work** by the group, but not monitoring it directly. The **main evaluator of results is the teacher** and, by giving feedback, the teacher tries to facilitate the processes of change and improvement inside the groups.

Furthermore, in the case of this course, the approach also responds to a strategy of **cooperative base groups**. This kind of groups are defined by Johnson et al. (1991) as those whose **functioning is long-term, their members are heterogeneous, their composition is permanent and their objective is that mutual support allows members to learn more and be more efficient in their tasks**.

Thus, we speak of **stable groups** that work together throughout the course, even though the activity of the participants includes **dynamics of interaction with participants from other groups**, especially in the presentation of the artefacts of the tasks (see Appendix 2).

Cooperative work in this course – group work – is not only desirable but also necessary, as it is intended to address complex knowledge in in-class contexts with a teacher-student ratio of around 1:80, and where the only way to expect larger tasks is through collective work.

However, the idea of achieving that all groups have a leading role in class, that there are explicit and frequent interactions between the groups and that they can receive weekly feedback from the teacher, has made us opt for a model of work in large groups. This means having a ratio of maximum **10 work groups per class (at a rate of between 6 and 9 members per group)**.

The activity of the groups is reflected not only in the work presented in class (see Appendix 2), but also in the so-called "**performance e-portfolio**" of the course. It is a public blog that aims at a weekly interaction with the content and the activity of the groups. This portfolio aims to collect the **group activity** around the tasks, and, in addition, each team member must collect the **conclusions** of his or her task on a weekly basis in the performance role that corresponds to him or her in each case (see Appendix 3).

This is a portfolio that should serve not only to show the **groups' reflection**, but also to serve as a **field notebook** to help them make subsequent decisions about each of the parts of that work, the **processes** they carry out to develop it and, of course, **how it could be**

improved. In addition, during the course, the importance of some of the elements of the portfolio is stressed as future reference material beyond the end of the course itself.

Appendix 2. Learning tasks in detail

Name	Topic	Summary	Artefact Development Strategy	Artefact format	Presentation Format	Presentation Strategy
T1. Conceptual Images	Intro: What is education nowadays?	Create 5 ideas about education, develop 5 phrases based on those ideas and finally create 5 squared photographs expressing those ideas	5 PRINTED conceptual images	Squared pictures	Wall Gallery	Gallery visit (no guides). Students from other groups try to guess what the meaning of the picture is. Big group reflection about the distance between attributed meaning Vs actual/original meaning. At the end, publication of the pictures on Instagram.
T2. TPACK	TPACK framework Graphic organisers	Choose an information map model to recreate the TPACK framework, and answer to some questions about it	Reading the recommended documents, watching the videos, and developing the information maps	A2 size information map	5 minutes presentation (repeated as many times as groups are in class)	Speed-learning format (5 minutes presentations in small groups that rotate during the session).
T3. Comic life	Potentialities of the ICT in the classroom Comics		Reading the documents about both topics, seeing the comic examples and developing the comic	Different types of Printed Comic: The possible formats are the following: • Cave art • Hieroglyphics • Before and after advertising • Auca (Cartoon) • Photo comics • Magazine cover • Superhero comic • Modern comic	Big group presentation explaining the decision-taking process to create the comic	Every group brings one copy of its comic for every group in the class. During the presentations, groups rate comics by clarity and readability.
T4. Under the Bloom's eyes	Web 2.0 tools learning potentials	Each group creates a video about basic features of some Web 2.0 tools (what is, how it works). Then in class, develop examples on how to use those tools for each objective of the Bloom's Taxonomy	Exploring the tool and creating the video Uploading the video to YouTube Reading the Churches's Review of the Bloom's Taxonomy Proposing uses of the tool for the different objectives	YouTube 1.5 min video Padlet combining Videos and Texts with potential uses of the tools	No presentation	In class videos are distributed randomly among the groups and they explore how to use the Web 2.0 tool of the video for each one of the Bloom's Taxonomy objective.

Name	Topic	Summary	Artefact Development Strategy	Artefact format	Presentation Format	Presentation Strategy
T5. Fair project	Learning design for: Digital Storytelling Stop motion Robots - programming	Groups will guide a predesigned activity of each one of the topics and will develop an original one for each one of them	Project based learning	They will present the learning design including examples of the final artefacts included on the activities	Presentation with Poster and examples	Students will create a fair with one stand by group in the Faculty hall and will present their ideas to colleagues and teachers from other groups. They will obtain feedback.
T6. My PLE	Personal Learning Environments (intro)	Groups will explore the PLE of one of the members of the group	Flipped classroom	Interactive pictures (Thinglink or Genially)	Big group presentation	Reflection on what of the PLE's expressed elements would be included on the different PLE's parts.
T7. Other's PLE	Personal Learning Environments as a Teacher's Professional development tool	Students will interview a teacher, will represent their PLE and will create a route-map to improve the PLE of this person	Problem based learning	PLE development advice in a Pechakucha's Slideshow	Pechakucha	Big Group Pechakucha Session and reflection together about the main improvable areas of PLEs.
T8. The dark side of textbooks	Textbooks	It addresses critical visions about textbooks	Design thinking	Infographic	Wall Gallery	Students will create a virtual museum including all the infographics created by their peers. They will also curate and organise an exposition using criteria that they will share using their blogs.
T9. Final portfolio	Metacognition processes	Students will develop a final e-portfolio including 5 of the tasks (at their choice) and the "Fair project"	Based on their feedback and work, choosing the tasks to include and create a web page	Web page	Free	10 minutes to develop the presentation in the format each group decides. After the presentation, the teacher asks at least 2 questions to each member about the e-portfolio's development, and their process of decision-taking.

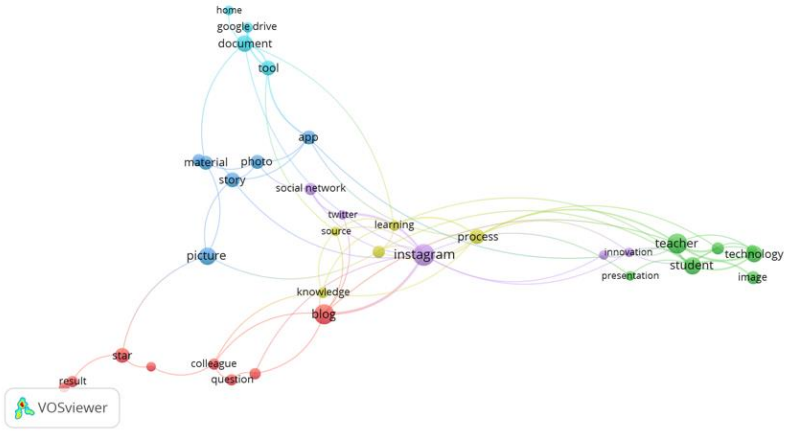
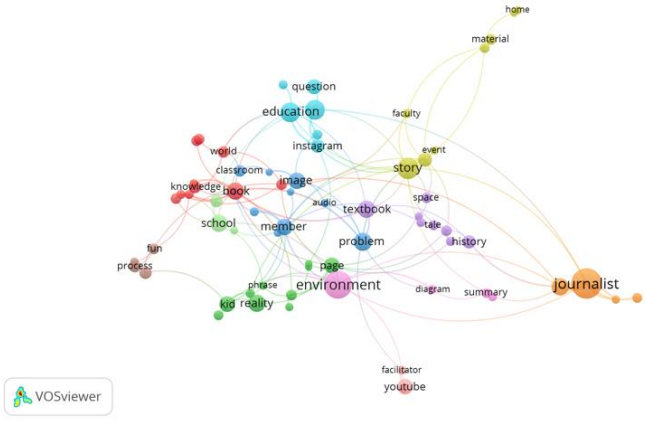
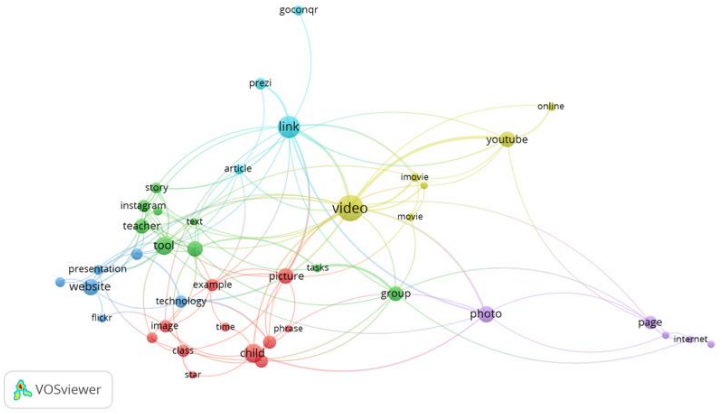
Appendix 3. Pre-established work roles definition

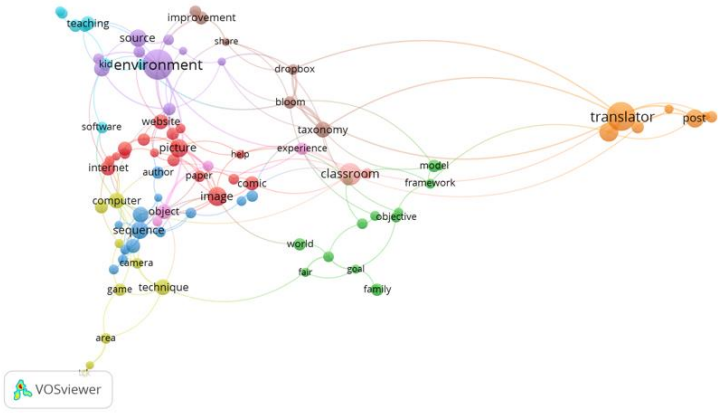
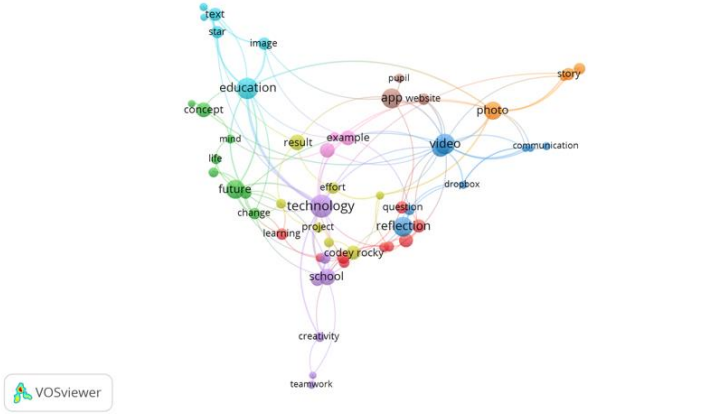
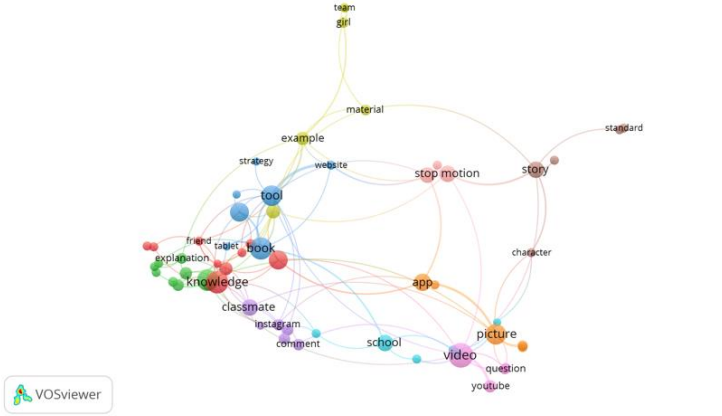
References: De Wever et al. (2010), Johnson et al. (1991), McKeachie et al. (1987) and Strijbos and De Laat (2010)

Role	Description
Facilitator	Defined in the learning design as the person that acts as the group leader being responsible for the task distribution, conflict mediation, checking the fulfilment of obligations, motivating and encouraging his/her classmates. Considered by some authors as a "helping role" (Johnson et al., 1991), and with evident inspiration in the roles of moderator in some of the proposals (De Wever et al., 2010), this person is crucial in the consolidation and well-functioning of the group.
Journalist	It is defined in the design as the student in charge of writing a weekly chronicle about what has happened in the group during the week and of documenting everything that happens in the group, being free to carry out his/her task in the format he/she considers more appropriate. Students are encouraged to 'tell their groups' stories' using the variety of formats provided by ICT. The post is expected to be useful as a group's field journal, allowing the group to take decisions about maintaining or modifying their internal work's dynamics. Besides, the journalist has the mission of exploring websites that may be interesting either for the course development or for the teacher training of the class members. The blog must include, at least, a reference to a website created by another class group and to another website generated by somebody outside the class, explaining the reasons of choice and leaving a comment in the website that is available for review.
Curator	The curator is responsible for compiling and organising in a schematic way all the information sources that the group has used for the development of the activity. Moreover, he/she must be in charge of sequencing the documents specifying the process carried out and linking and citing (according to APA style) the aforementioned documents in a diagram (mind map). This mechanism enables students to represent part of the cognitive structure implemented for the concrete task (McKeachie et al., 1987, p. 15). This role can also be included within the roles which help the group. Although it is true that sometimes the curator also assumes a summarizer role, it is also true that his/her role does not imply a proper summary, but a compilation that may be useful beyond this course.
Translator	Inspired by roles such as theoreticians of other proposals such as that of De Wever et al. (2010), this role can be classified by function, among those that help students formulate what they know and integrate that knowledge, as well as those that seek to encourage students' thinking and improve their reasoning (Johnson et al., 1991). The translator role is designed to define, every week, the five core terms related to the course which have been worked in the activity. This role is considered particularly relevant in the course's learning design since the student must take charge of, not only selecting the five substantial issues of that week, but also of re-elaborating and building those key terms. The role instructions emphasize the need of 'discussing' with the authors, specifically mentioning the possibility of 'borrowing' someone's words, letting them flow in our speech, properly cited. But, what's more, this role involves answering and including in the post a specific question, apart from the five terms. This question refers to detailing the weaknesses of the topic, the methodology or tool tackled in the task and the decisions about which aspects should be explicit in order to achieve the best implementation setting or, at least, to avoid non-desirable influences in the educational processes.

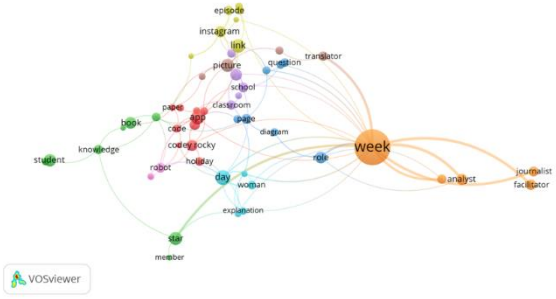
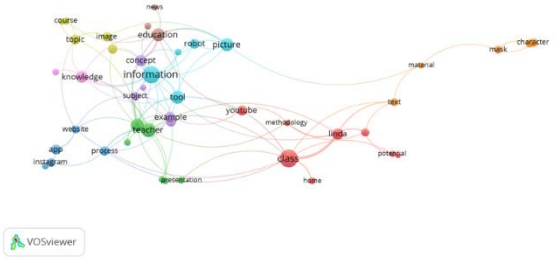
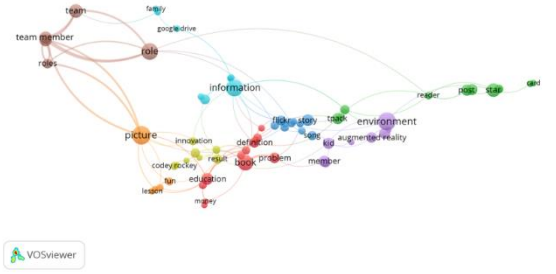
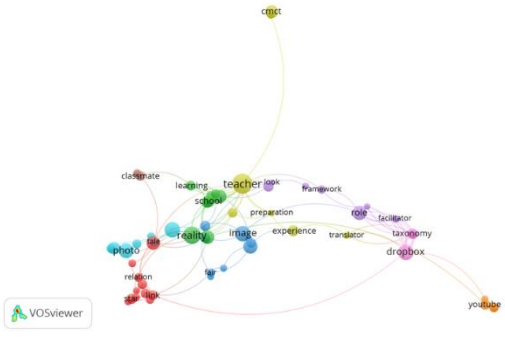
Role	Description
Analyst	The analyst is the role in charge of conducting the assignment's final reflection and the weekly evaluation of the group members' performance. The performance evaluation is carried out following a general rubric, which enables analysts to value the contribution of each group member. At the end of each week, each analyst must include that evaluation (numerical and qualitative) in an online ad-hoc questionnaire. In addition to this assignment, the analyst is responsible for making the weekly reflection of the team, which should include comments on what they have learned both on the contents of the course, as on group work, as well as for becoming a teacher. This role is inspired by the role of "Analyst" described in some of the works referred to in Strijbos and De Laat (2010) and it is designed as one of the most important roles of the work. Not in vain, the role is in charge of carrying out the reflection of the work, paying attention to the work carried out by all the other roles, looking on what aspects they have approached, thinking about how they have worked and agreeing with their colleagues on a reflection on what they have learned. Ultimately, she or he is in charge of explaining and agreeing on the process of reflection and metacognition of the team.
Star	This role is in charge of presenting to all the class members the final product of the weekly tasks, paying attention to the specified requirements in each task. It must be emphasised that, despite the fact that all the team members should be involved in the achievement of the task, the star has shown a greater interest each week.

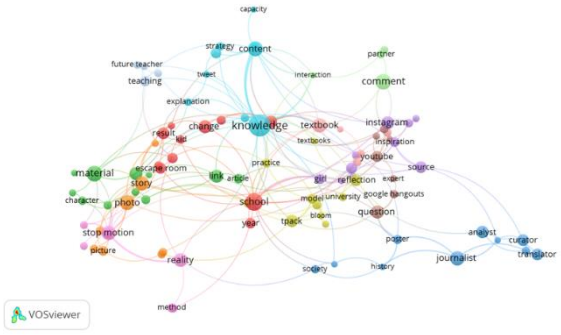
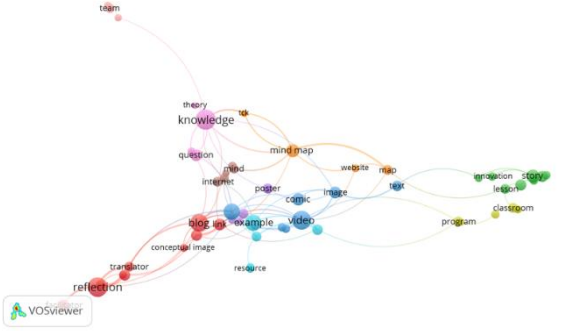
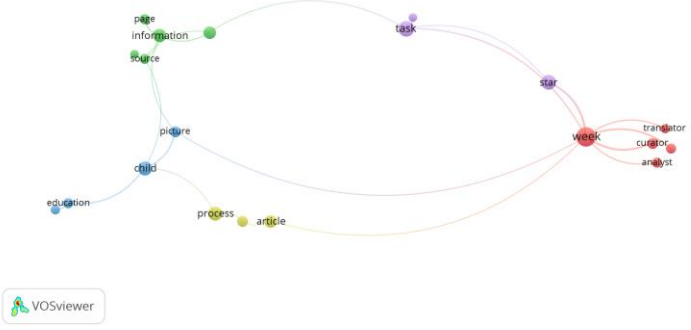
Appendix 4. VNA maps by roles

Role	Map
Facilitator	
Journalist	
Curator	

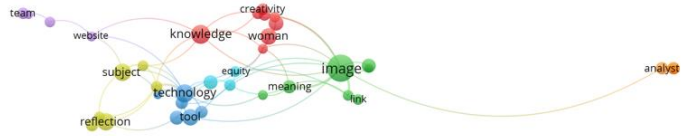
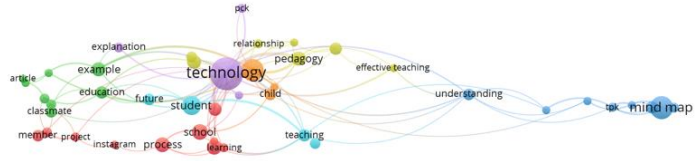
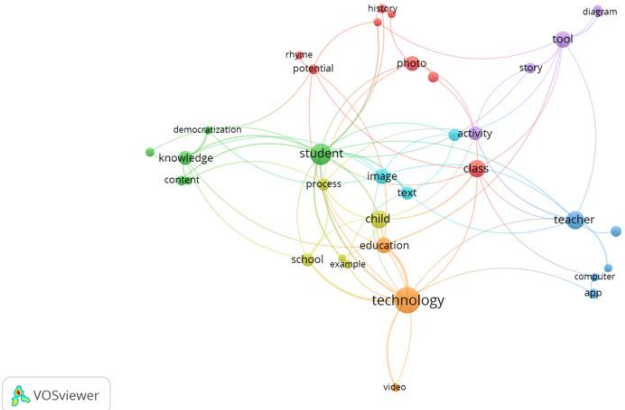
Role	Map
Translator	
Analyst	
Star	

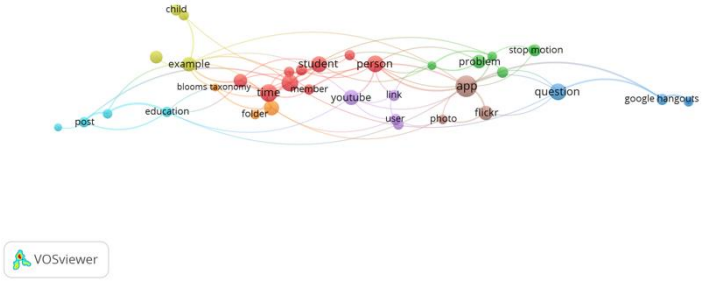
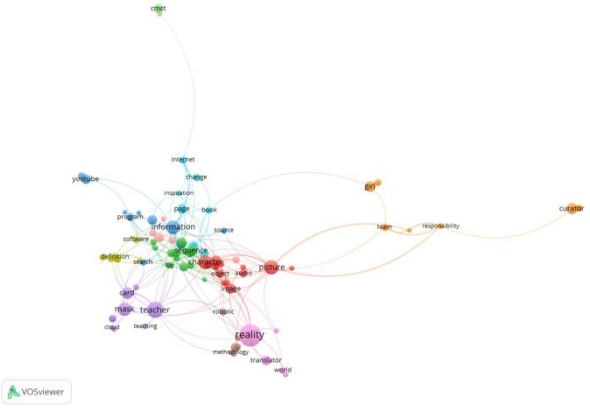
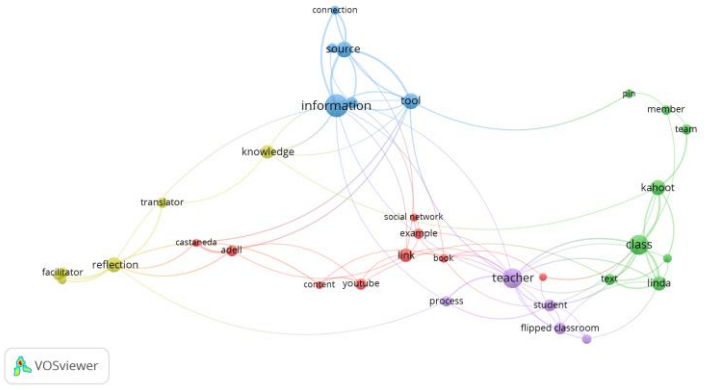
Appendix 5. VNA maps by groups

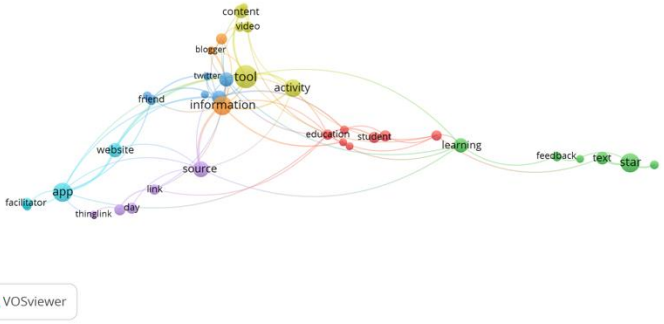
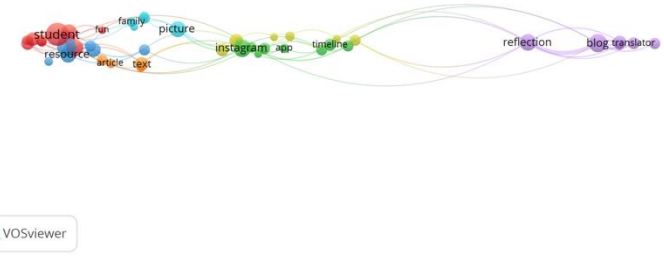
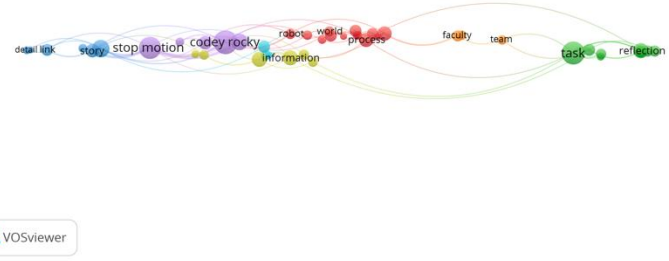
Role	Map
Group 1	
Group 2	
Group 3	
Group 4	

Role	Map
Group 5	
Group 6	
Group 7	

Appendix 6. VNA maps by task

Task	Map
Task 1 Conceptual images	
Task 2 TPACK	
Task 3 Comic life	

Task	Map
Task 4 Under the Bloom's eyes	
Task 5 Fair project	
Task 6 My PLE	

Task	Map
Task 7 Other's PLE	
Task 8 The dark side of textbooks	
Task 9 Final portfolio	

Appendix 7. Final questionnaire items

Regarding roles

About the roles of work developed, mark one of the following options (being 1 nothing and 10 a lot)

Role (there are the same questions for each one of the scripted roles of the course)

Item	Scale
Level of difficulty	From 1 to 10
Level of satisfaction	From 1 to 10
Applicability in the real world	From 1 to 10
Relevance in the group work	From 1 to 10
Relevance of what I have learned	From 1 to 10
I am doing this for my future	From 1 to 10

Regarding tasks

About the tasks done during the course, mark one of the following options (being 1 nothing and 10 a lot)

Task (there are the same questions for each one of the course tasks)

Item	Scale
I like the topic worked	From 1 to 10
I think the topic is important	From 1 to 10
I learned about ICT	From 1 to 10
I learned about Primary Education	From 1 to 10
This task is applicable to my professional future	From 1 to 10
I found difficulties during the development of the task in English	From 1 to 10
I found difficulties during the presentation of the task in English	From 1 to 10

Regarding groups

Task (there are the same questions for each one of the course tasks)

Item	Scale
I am pleased with my individual work	From 1 to 10
I am pleased with the group work	From 1 to 10

Other Questions:

Item	Scale
From your point of view what is the BEST part of the experience?	Open
From your point of view what is the WORST part of the experience?	Open
Have you learned contents from other subjects in this course?	Multiple choice: • Yes • No • Maybe
What is your opinion about the work of other groups in this course?	Multiple choice: • Sincerely, I don't know their work • We all have very similar levels • Most of them have problems to develop the tasks properly • Most of them are better than us

Item	Scale
How close is your relationship with the other groups of the class?	Multiple choice: • I don't have almost any relationship • Correct and polite but distant with the majority of them • I have many friends in class, I feel very close to them
How do you describe the relationship of your group with the teacher?	Multiple choice: • We don't have almost any • Correct and polite but distant • She is kind and friendly, she cares about us • She is especially dry with our group, we have the impression to bother her
Do you think that the experiences you have had in this course will improve the way you learn in the future?	Multiple choice: • Yes • No • Maybe
What would you like change in the task? Please write it in the following chart.	Open

Regarding material aspects

Item	Scale
Did you read the activity instructions before class?	Multiple choice: • Always • Often • Sometimes • Occasionally • Never
Do you read the documents (watch the recommended videos, or presentations) to do the activities?	Multiple choice: • Always • Often • Sometimes • Occasionally • Never
How do you normally read documents in the class?	Multiple choice: • I don't read in class • I print them • I read them in a tablet • I read them in a mobile phone • I read them in a laptop • I read them in other device
How do you normally read documents at home?	Multiple choice: • I don't read at home • I print them • I read them in a tablet • I read them in a mobile phone • I read them in a laptop • I read them in other device
Do you take notes while you are reading?	Multiple choice: • No, I don't • In a paper/notebook • In a tablet • In a mobile phone • In a laptop
How is the relationship with the teacher?	Multiple choice: • We don't have almost any • Correct and polite but distant • She is kind and friendly, she cares about us

Item	Scale
	• She is especially dry with our group, we have the impression to bother her
How do you prefer to carry out the activities?	Multiple choice: • Always • Often • Sometimes • Occasionally • Never
Apart from the documents that the teacher included in the activities, have you (YOU, not your group) included in your work, theory from other resources/document/video/paper/web?	Multiple choice: • Always • Often • Sometimes • Occasionally • Never
Have you connected anything said in class with something heard or read outside the university?	Multiple choice: • Always • Often • Sometimes • Occasionally • Never
Please pick the 3 physical spaces where your group have done most activity of the course (just 3, please)	Multiple choice: • The classroom • House of one of us • In specific faculty spaces (cabins) • In the canteen • In the library • Other
Please name the 3 physical spaces where YOU (individually) have done most activity of the course (just 3, please)	Multiple choice: • The classroom • My home • In specific faculty spaces (cabins) • In the canteen • In the library • Other

In the case of each tool, please indicate how important it has been for the development of the course (for you).

Tools (there is one entire item by each tool with the whole pool of options)	Scale (Choose one)
• LMS • Email • Instagram • WhatsApp • Twitter • Google Drive • Genially • Wikipedia • YouTube	• I don't know what it is. • We could do without using it. • We use it sometimes as a fundamental part of the activity. • We use it sometimes to make the activity funnier/prettier. • We use it often as a fundamental part of the activity. • We use it often to make the activity funnier/prettier.

In the case of each DEVICE, please indicate how important it has been for the development of the course (for you).

Devices (there is one entire item by each device with the whole pool of options)	Scale (Choose one)
• Mobile Phone • Laptop • Notebook or Paper • Robot • Tablet • Whiteboard • Camera	• I don't know what it is. • We could do without using it. • We use it sometimes as a fundamental part of the activity. • We use it sometimes to make the activity funnier/prettier. • We use it often as a fundamental part of the activity. • We use it often to make the activity funnier/prettier.

Abbreviations

ECTS: European Credit Transfer System; LMS: Learning Management System; PAH: Pedagogy-andragogy-heutagogy; PDP: Participant's declared performance; PLE: Personal Learning Environment; SDP: Students' declared performance; VNA: Visual network analysis.

Endnotes

[a] We use the terminology of the ACAD framework (Goodyear & Carvalho, 2014). [b] Due to readability reasons, only a summary of the elements is provided here. More information can be found in Appendices 1 to 3. Also, the analysis of these elements has been already object of publication (see Castañeda, 2019).

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Authors' contributions

LC is the teacher of the case study. Both authors contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

Due to the nature of this research, participants of the case study did not agree for their data to be shared publicly, so supporting data is not available.

Declarations

Competing interests

The authorship team declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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