Student-Generated Teaching Materials: A Scoping Review Mapping the Research Field

Materiales didácticos generados por los estudiantes: una revisión panorámica para mapear el campo de investigación

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ABSTRACT

Students can create products that take the form of instructional materials. A scoping review was carried out to map the research field of student-generated teaching materials, focusing on product types, information sources, learning-related matters, and researchers' explanations. Based on 280 articles, four product types were identified: audio/visual materials, questions, texts, and educational games. Studies gathered information from product creation, product use, participants' perceptions, and learning outcomes. Socio-cognitive and motivational learning-related matters for creators and users were reported concerning the subject matter, cross-curricular competencies, academic emotions, and engagement. In these studies, researchers interpreted their findings based on nine different explanations: active learning, audience effect, knowledge building, learning by teaching, motivational processes, peer learning, the role of ICT, scaffolding, and time-on-task and practice effect. Different lines for future research are discussed, related to the educational stages and knowledge areas, the research designs, and the relationship between research and practice.

RESUMEN

Los estudiantes pueden crear productos que tomen la forma de materiales didácticos. Se llevó a cabo una revisión panorámica de la literatura para mapear el campo de investigación de los materiales didácticos generados por estudiantes, centrándose en los tipos de productos, las fuentes de información, los aspectos relacionados con el aprendizaje, y las explicaciones de los investigadores. A partir del análisis de 280 artículos, se identificaron cuatro tipos de productos: materiales audiovisuales, preguntas, textos y juegos educativos. Los estudios recopilaron información de la creación del producto, el uso del producto, las percepciones de los participantes y los resultados de aprendizaje. Se reportaron aspectos sociocognitivos y motivacionales relacionados con el aprendizaje de los creadores y usuarios, en referencia al contenido, las competencias transversales, las emociones académicas y la implicación –engagement–. En estos estudios, los investigadores interpretaron sus hallazgos basándose en nueve explicaciones diferentes: aprendizaje activo, efecto audiencia, construcción de conocimiento, aprender enseñando, procesos motivacionales, aprendizaje entre iguales, el papel de las TIC, andamiaje, y el efecto de la práctica y el tiempo en la tarea. Se discuten diferentes líneas de investigación futura, relacionadas con las etapas educativas y las áreas de conocimiento, los diseños de investigación, y la relación entre investigación y práctica.

1. Introduction

With the increase of student-centered practices mainly based on Dewey's learning by doing (1938), students have been more and more involved in active tasks that usually require them to generate products. From a historical perspective, the potential of generating artefacts has been highlighted both for their cultural function and for the thinking processes of the artefact creators (Bruner, 1996; Meyerson, 1948; Wertsch, 1985). There are plenty of external representation systems that can act as an extension of memory but also enable new ways of knowing and operating on symbolic worlds (Pérez-Echeverría et al., 2010; Vygotsky, 1978). When students generate artefacts, they can learn how to use external representation systems as epistemic tools to boost their thinking processes.

Student-generated artefacts may adopt many different forms and respond to several purposes (Snelson, 2018). Sometimes these products aim to show the community what students have been working on and celebrate learning, as usually happens in project-based learning (Chen & Yang, 2019). However, other products might take the form of instructional materials, that is, artefacts that can be used by others to learn. In this case, the students who create the product expect that someone will use the artefact with learning purposes, just as teachers do when they create instructional or teaching materials.

Several literature reviews on the use of videos for teaching and learning found that one of its least frequent uses has to do with its creation by the students (Kay, 2012; McGarr, 2009; Winslett, 2014). The emergence and development of Web 2.0 authoring tools may foster the possibilities of having students create content in multiple forms, such as audio and video podcasting, blogging, social bookmarking, social networking, virtual world activities, and wiki writing (Gray et al., 2010), as well as educational computer games (Hava & Cakir, 2017). Most literature reviews on student-generated materials focused on media creation.

Snelson's (2018) review on video production in content-area pedagogy analyzed 61 studies from 20 different content areas. Other literature reviews focused on specific content areas. This is the case of Reyna and Meier (2018a), who analyzed student-generated media in tertiary science education; Gallardo-Williams et al. (2020), who focused on student-generated video in chemistry education; and Farrokhnia et al. (2020), who explored the creation of stop-motion animation in science classes. Some common trends emerge from the findings of these literature reviews.

First, even when the focus is on specific products, prior literature reviews found a wide diversity of student-generated materials. Moreover, these different kinds of products could adopt several purposes. For instance, Snelson (2018) points to five purposes for video production: information-oriented videos, which had students present course-related topics; performance-oriented videos, used to document, reflect on, or critique performance skills; composition-oriented videos, which emphasized multimodal composition with images, text, and sound; literacy-oriented videos, which underlined the development of one or more literacies; and creativity-oriented videos, focused on the development and expression of creativity.

Second, the studies analyzed in these literature reviews reported cognitive and motivational learning outcomes. Within the cognitive outcomes, all prior literature reviews point to both domain-specific knowledge and domain-general skills (Farrokhnia et al., 2020; Gallardo-Williams et al., 2020; Gray et al., 2010; Reyna & Meier, 2018a; Snelson, 2018). To explore these outcomes, data has been gathered from different sources. For instance, Snelson (2018) reported that the studies gathered data from learner perceptions, the video creation process, the assessment of the final video, or a combination of them. Other reviews also reported the use of grade point average and exam scores (Farrokhnia et al., 2020; Reyna & Meier, 2018a).

Third, practices involving the generation of materials by students may take place in different education settings and stages, although higher education gathers most studies (Farrokhnia et al., 2020; Gallardo-Williams et al., 2020; Gray et al., 2010; Reyna & Meier, 2018a; Snelson, 2018). The wide diversity in terms of products, purposes and education settings poses some issues regarding the decisions that must be made in each specific practice to support student generation of materials —for instance, related to scaffolding techniques, student grouping and topic selection (Farrokhnia et al., 2020).

Fourth, to a greater or lesser extent, all prior literature reviews suggest an attempt to find a shared theoretical framework for practices involving student-generated materials. This is explicitly stated by Reyna and Meier (2018a), who developed a practical model (Reyna & Meier, 2018b) and a taxonomy of digital media types (Reyna et al., 2017) to guide academics and students on the implementation of practices involving the student generation of media.

As pointed out by Gray et al. (2010), having students in the role of content creators might eventually form a collection of learning resources for other students, in line with Contributing Student Pedagogy (CSP), first formulated by Collis and Moonen (2005). Founded upon constructivism and socio-cultural constructivism, CSP

emphasizes the process of learning by engaging students as co-creators of learning resources (Hamer et al., 2012). Its definition includes two components: having students contribute to the learning of others —as content creators—, and value the contributions of others —as content users— (Hamer et al., 2008). According to Hamer et al. (2008, p. 194), in CSP "the roles and responsibilities of 'teacher' and 'student' are fluid". The implications of this sentence —students can act as teachers— resonate with another theoretical perspective that has backed up the student creation of teaching materials: learning by teaching, which emphasizes the learning opportunities for students in the teacher's role (Duran, 2017; Duran & Topping, 2017; Fiorella & Mayer, 2014; Hoogerheide et al., 2019; Kobayashi, 2019; Roscoe, 2014).

In a nutshell, the field of study of student-generated teaching materials remains rather disorganized. There are disperse studies and separate lines of research that mainly focus on specific products, rather than on the psychological processes involved in the creation of teaching materials. Some attempts have been made to find a shared theoretical framework, such as contributing student pedagogy (Hamer et al., 2008) and learning by teaching (Duran & Topping, 2017). With the aim of mapping the research field, this literature review takes the form of a scoping review (Arksey & O'Malley, 2005; Pham et al., 2014). Four research questions are addressed:

(1) What types of products do students generate as teaching materials?
(2) What sources of information do studies collect data from?
(3) What learning-related matters do studies analyze?
(4) What explanations do researchers use to discuss their findings?

2. Method

2.1. Type of literature review

A scoping review was carried out (Arksey & O'Malley, 2005; Pham et al., 2014), since it is appropriate for a complex area that has not been reviewed comprehensively before (Arksey & O'Malley, 2005). Scoping reviews aim at mapping the literature of the topic to identify key concepts, research gaps, and types and sources of evidence to inform practice, policymaking, and research (Daudt et al., 2013). Unlike other kinds of reviews, they provide an initial indication of the potential size and nature of the extant literature on a topic, focusing on the breadth of coverage of the literature rather than the depth of coverage, with the goal of being as comprehensive as possible (García-Peñalvo, 2022; Paré et al., 2015).

2.2. Information sources, search process and study selection

After defining the research questions, relevant studies were identified in a first search. This enabled the definition of search terms (Table 1), as well as the elaboration of the following eligibility criteria—to accept only articles:

- Published in peer-reviewed journals, to promote higher standards of research quality. This excludes papers published in conference proceedings, reports, and doctoral theses.
- In which data is systematically gathered. This excludes articles describing projects without gathering any data on the assessment of the project implementation, as well as anecdotal evidence.
- That report students creating teaching materials, with the aim that the addressee learns from it. This excludes student-generated materials with other purposes rather than teaching, such as entertaining or expressing artistically.
- In which the teaching material is intentionally created by students with the expectation that a real, potential, or imaginary addressee can learn from it. This excludes articles that report students creating content as a learning task only directed to the teacher or with no addressee.
- In which the teaching material created by students allows the addressee to autonomously learn from it. This excludes articles that report students creating materials to be used as a support for their interaction with the addressee, such as in peer tutoring or oral presentations before the class.
- In which the focus of the study is on student-generated teaching materials. This excludes articles in which student-generated teaching materials are not the focus, are among other kinds of products or are only a small part of the study.

Table 1. Search terms

Concepts	Related search terms
Student-generated	"student-generated" OR "student-created" OR "student-produced" OR "student-made" OR "pupil-generated" OR "pupil-created" OR "pupil-produced" OR "pupil-made" OR "learner-generated" OR "learner-created" OR "learner-produced" OR "learner-made" OR "generative learning"
Materials	material OR artefact OR content OR resource OR tutorial OR media OR video OR screencast OR podcast OR digital story OR animation OR question OR multiple-choice OR textbook OR book OR wiki OR blog
Learning by teaching	"learning-by-teaching" OR "peer instruction" OR "peer-to-peer instruction" OR "peer teaching" OR "student-as-teacher"

At the end of February 2020, four databases were used to find relevant articles—ERIC, PsycInfo, Scopus and Web of Science—, from any educational stage and publication year, using keywords and Boolean operators (OR between related search terms, AND between concepts). Search results were 89 documents in ERIC, 20 in PsycInfo, 5 in Scopus, and 10 in Web of Science. The eligibility criteria were used, reading the abstract and checking the full article if necessary. Considering duplicates and eligibility criteria, 7 articles were selected. After reading these remaining articles, the search terms were refined to spot some other articles that might not be explicitly using keywords related to learning by teaching. Considering that this would be tackled by the eligibility criteria, the terms related to the concept of learning by teaching were excluded. The other two concepts were combined in the search terms, considering the different kinds of materials (i.e., "student-generated media"). This second search obtained much bigger results: 2360 in ERIC, 61 in PsycInfo, 487 in Scopus and 203 in Web of Science. Considering duplicates and eligibility criteria, a total of 225 articles were selected—including the 7 articles selected from the first search. Snowballing, that is, checking the reference list of a paper to identify additional studies (Wohlin, 2014), was carried out in the prior literature reviews. After considering eligibility criteria, 55 additional articles were selected. This makes a total of 280 articles selected for this scoping review (see Supplemental online material).

2.3. Data collection and analysis

The two authors first read 20 articles and took notes as a starting point for content analysis, which was later carried out with the 280 articles by the first author using the data analysis computer program Atlas.ti 8. As suggested by Arksey and O'Malley (2005), both general information about each study and specific information related to the research questions were gathered. During the analysis, the two authors discussed when necessary to tackle the coding issues. Several emerging themes were defined and redefined during the process, until reaching agreement. At the end of the analysis, a meeting between the authors took place to summarize and interpret the results.

3. Results

The findings of the scoping review on student-generated teaching materials are presented for each of the four research questions below. A summary of data can be consulted in Supplemental online material.

3.1. Types of generated products

The analysis of the articles shows a wide variety of interventions involving student-generated materials. This literature review focuses on type of product, considering that as a first step towards the understanding and spread of this kind of educational practices it is necessary to identify the artefacts that can fulfil a learning-by-teaching function.

Four main groups of student-generated teaching materials are identified: audio/visual materials (145 articles), questions (55), texts (49), and educational games (29). Ten articles could have been classified into different groups, because they asked students to generate different kinds of products. They were only classified in one of the groups based on which the most prominent product was. Two articles could not be classified in any group: creation of a model for the environmental knowledge of blind students (Papadopoulos, 2004), and creation of

drawings and sculptures to represent pollination (Danish & Enyedy, 2007). General features of the articles are presented in Table 2. Percentages are calculated over total articles for the group of articles referred to in each column: Audio/visual materials (145), Questions (55), Texts (49), Educational games (29), Total (280). Consider that two articles are not included in any of the four groups of products but only in the total.

Table 2. General features of included articles

	Audio/visual		Questions		Texts		Ed. games		Total	
	f	%	f	%	f	%	f	%	f	%
Publication year										
Feb. 2020-2016	70	48.28	26	47.27	12	24.49	9	31.03	117	41.79
2015-2012	51	35.17	14	25.45	15	30.61	9	31.03	89	31.79
2011-2008	20	13.79	6	10.91	8	16.33	8	27.59	42	15.00
2007-2004	1	0.69	4	7.27	4	8.16	0	0.00	11	3.93
2003-2000	1	0.69	1	1.82	3	6.12	0	0.00	5	1.79
<2000	2	1.38	4	7.27	7	14.29	3	10.34	16	5.71
Educational stage										
Higher ed.	108	74.48	45	81.82	42	85.71	10	34.48	205	73.21
Secondary ed.	19	13.10	7	12.73	5	10.20	10	34.48	42	15.00
Primary ed.	11	7.59	3	5.45	2	4.08	9	31.03	25	8.93
Multiple stages	7	4.83	0	0.00	0	0.00	0	0.00	8	2.86
Knowledge area										
Formal sciences	6	4.14	1	1.82	0	0.00	2	6.90	9	3.21
Natural sciences	30	20.69	14	25.45	10	20.41	8	27.59	63	22.50
Social sciences	66	45.52	17	30.91	26	53.06	13	44.83	123	43.93
Applied sciences	31	21.38	22	40.00	10	20.41	6	20.69	69	24.64
Humanities	3	2.07	0	0.00	2	4.08	0	0.00	5	1.79
Multiple areas	9	6.21	1	1.82	1	2.04	0	0.00	11	3.93
Research design										
RCT	3	2.07	1	1.82	1	2.04	0	0.00	5	1.79
Quasi-experimental	16	11.03	10	18.18	4	8.16	6	20.69	37	13.21
Correlational	9	6.21	9	16.36	0	0.00	0	0.00	18	6.43
Mixed methods	21	14.48	8	14.55	10	20.41	5	17.24	44	15.71
Case study	28	19.31	4	7.27	11	22.45	10	34.48	54	19.29
Descriptive	61	42.07	23	41.82	22	44.90	6	20.69	112	40.00
Participatory	7	4.83	0	0.00	1	2.04	2	6.90	10	3.57

Note: Educational stage coded based on content creator. RCT stands for Randomized Controlled Trial.

Data shows a substantial increase in the number of publications in the recent years, especially in audio/visual materials and questions. As regards educational stage, most articles come from higher education, except for the group of educational games—which shows a balance between higher, secondary, and primary education. Concerning knowledge area, social sciences gather nearly half of the articles, but natural sciences and applied sciences reach considerable frequencies as well. As for research design, most studies adopt a descriptive design, with case study, mixed methods and quasi-experimental designs following far behind. As regards quasi-experimental designs: 10 articles carry out one-group pretest-posttest designs, 14 posttest-only control group designs, and 13 pretest-posttest control group designs. As for mixed methods designs: 14 articles adopt triangulation designs, 23 embedded designs—4 embedded correlational and 19 embedded quasi-experimental—, and 8 explanatory designs. Within embedded and explanatory designs: 5 articles make use of one-group pretest-posttest designs, 11 posttest-only control group designs, and 8 pretest-posttest control group designs.

3.1.1. Student-generated audio/visual materials

145 articles reported interventions in which students generated audio/visual materials, gathering a wide variety of products: photos, posters, slide presentations, comics, storyboards, campaigns, audio podcasts, and videos. Videos are especially flexible, and can adopt different formats, such as screencasts, video tutorials, video blogs, video lectures, narrated videos, recorded events, documentaries, and digital storytelling. The products can be created in groups or individually. Student-generated media can be used in the class context, but they can also involve the educational community both in the creation and as audience.

3.1.2. Student-generated questions

55 articles reported interventions in which students generated questions, tests, exercises, or practice activities for others. Different kinds of tasks are included (i.e., matching, true or false, short-answer, multiple-choice). Students may also be asked to generate feedback for potential answerers. Questions may be created and published on its own or may belong to a test or a vignette created by the students. The creators can also be asked to use and cite peer-generated questions to create a test. Student-generated questions are usually created individually, but collaboration may emerge in the form of peer review. They are used in virtual platforms, discussions in class, mock exams or even in final exams.

3.1.3. Student-generated texts

49 articles reported interventions in which students generated text entries. Although these text entries could also contain multimedia and/or questions, they were included in this group of materials considering the main role of text in hypertext products. Many of these interventions take the form of student-led wikis, which become living textbooks, but there are also other kinds of products that work as student-generated texts, such as blogs, websites, eBooks, magazines, shared lecture notes and argumentative letters. Although text entries can be created in groups or individually, tasks usually show a collaborative nature either throughout the creation process or in peer review and further use. These student-generated texts are usually used in the course as learning and study resources.

3.1.4. Student-generated educational games

29 articles reported interventions in which students generated educational games— games with an educational purpose besides entertainment. Although some of them might be based on the creation of questions or involve the generation of audio/visual elements, they were included in this group considering the game genre. These interventions include the creation of board games, puzzles, quiz games, videogames, PowerPoint games, simulations, and virtual worlds. These interventions may involve the creation of instructions so that the user is clear about the goal and the mechanics of the game. The products can be created in groups or individually. Even when created individually, collaboration is usually present either by informally asking peers for help or by playing others' games and providing feedback. Student-generated educational games are usually designed and used as practice or review materials for peers, or as teaching materials for younger students. Pilot testing is often carried out, with the target users or with peers.

3.2. Sources of information

The analyzed articles collect data from four main sources of information: product creation, use of the product, participants' perceptions, and learning outcomes.

3.2.1. Product creation

145 articles obtain information from the analysis of the product creation process and/or the final output generated by students. The former includes observations, field notes, logs, think-aloud protocols, intermediate

documents, or activities, and reported time invested in creating the material. The latter considers the assessment of the final teaching material.

3.2.2. Use of the product

65 articles obtain information from the analysis of the use that other people make of student-generated materials. It includes its use in course activities, mock exams or tests, and events for sharing the teaching material with the target audience. Data is mainly gathered through indicators of use of the teaching material, such as user logs, ratings, comments, and reported time invested in using the material.

3.2.3. Participants' perceptions

226 articles obtain information from the analysis of perceptions of participants in the intervention: mainly students—who can act as creators or users of the materials—, but also teachers, and even parents in few cases. These are gathered by means of surveys, self-report questionnaires, interviews, focus groups, reflective reports or learning diaries.

3.2.4. Learning outcomes

94 articles obtain information from the analysis of measures of knowledge acquired by students, gathered mainly in tests or exams—either specific tests for the task being assessed or general exams from the course in which the task is carried out.

3.3. Learning-related matters

The analysis of the learning-related matters reported in the articles show that they focus on the socio-cognitive and motivational dimensions of learning. Two broad themes for each dimension were identified: subject matter and cross-curricular competencies—socio-cognitive dimension—, and academic emotions and engagement—motivational dimension—(Table 3). As for the socio-cognitive dimension, the distinction between subject matter and cross-curricular competencies is in line with the separation between domain-specific knowledge and domain-general skills, pointed out in prior reviews in the field of student-generated materials (Farrokhnia et al., 2020; Gallardo-Williams et al., 2020; Gray et al., 2010; Reyna & Meier, 2018a; Snelson, 2018). Regarding the motivational dimension, the distinction between academic emotions and engagement is based on Pekrun and Linnenbrink-Garcia (2012): academic emotions are defined as the emotional experiences of students in academic settings, including general and specific mood, as well as achievement, epistemic, topic and social emotions; and motivational engagement refers to motivational processes directed toward task involvement. Results for each theme are presented separating between creator and user. The former is the student or group of students who creates the teaching material. The latter refers to the person who uses—or may potentially use—the teaching material, including the role of students as peer-reviewers.

Table 3. Learning-related matters reported in the articles

	Creator		User	
	f	%	f	%
Socio-cognitive dimension				
Subject matter	220	78.57	165	58.93
Cross-curricular competencies	199	71.07	51	18.21
Motivational dimension				
Academic emotions	178	63.57	82	29.29
Engagement	140	50.00	76	27.14

Note: Percentages calculated over total number of articles (280).

Data shows that the analyzed articles provide a considerable amount of information for both the socio-cognitive and the motivational dimension, especially for the former. As regards the student role, articles provide more information about the material creator rather than the user. The user's cross-curricular competencies are the least-researched theme.

3.3.1. Subject matter

Creator. 220 articles provided information about creator's subject matter. The main emergent descriptors were: declarative and/or procedural knowledge about the subject matter; degree of accuracy—and misconceptions—; relevance of the ideas or actions in relation to the target topic; organization of ideas about the topic; degree of deep thinking; meaning making processes and activities.

User. 165 articles provided information about user's subject matter. The main emergent descriptors were: usefulness for improving the user's declarative and/or procedural knowledge about the subject matter; learning potential as a peer reviewer of student-generated teaching materials; trust—and mistrust—in the quality and accuracy of student-generated teaching materials.

3.3.2. Cross-curricular competencies

Creator. 199 articles provided information about creator's cross-curricular competencies. The main emergent descriptors were: use of Information and Communications Technology (ICT); information searching skills; communication skills; writing skills; teamwork skills; social skills; teaching skills; open-mindedness and perspective-taking; self-directedness; critical thinking and meta-awareness; problem-solving skills; creativity; cognitive and metacognitive skills; study habits and academic competencies; knowledge of the product features and its process of creation.

User. 51 articles provided information about user's cross-curricular competencies. The main emergent descriptors were: critical thinking and communication skills for giving feedback; responsibility and sense of community; open-mindedness and perspective-taking; empathy and respect towards others—including cross-cultural learning—; ease of use of the student-generated teaching materials; usefulness of the student-generated teaching material as a model for learning product features and options.

3.3.3. Academic emotions

Creator. 178 articles provided information about creator's academic emotions. The main emergent descriptors were: task value; preference compared to other kind of tasks; recommendation of further use in the future; positive/negative and activating/deactivating emotions—also considering the role of the audience in the creator's emotions—; interest or motivation towards the subject matter; self-confidence—with the subject matter or with the use of tools.

User. 82 articles provided information about user's academic emotions. The main emergent descriptors were: task value; preference compared to other kind of tasks; recommendation of further use in the future; positive/negative and activating/deactivating emotions; interest or motivation towards the subject matter; self-confidence—with the subject matter or with the use of tools.

3.3.4. Engagement

Creator. 140 articles provided information about creator's engagement. The main emergent descriptors were: participation and involvement in the task; factors that promote or hinder engagement, such as time and effort, novelty, audience, teacher guidance, choice and sense of ownership, assessment issues and marks provided for the task.

User. 76 articles provided information about user's engagement. The main emergent descriptors were: participation and involvement in the task—as users or as peer-reviewers—; factors that promote or hinder engagement, such as specific features of the product, investment of time, perceived usefulness, assessment issues and marks provided for the task.

3.4. Researchers' explanations

Besides subject-specific explanations, researchers interpret their findings about student-generated teaching materials based on different explanations, for the creator and for the user (Table 4). These nine explanations are not mutually exclusive.

Table 4. Researchers' explanations provided in the articles

	Creator		**User**	
	f	*%*	*f*	*%*
Active learning	163	58.21	21	7.50
Audience effect	71	25.36	4	1.43
Knowledge building	141	50.36	28	10.00
Learning by teaching	27	9.64	1	0.36
Motivational processes	161	57.50	43	15.36
Peer learning	127	45.36	68	24.29
Role of ICT	143	51.07	56	20.00
Scaffolding	106	37.86	21	7.50
Time-on-task and practice effect	76	27.14	26	9.29

Note: Percentages calculated over total number of articles (280).

Data shows that the analyzed articles provide more explanations for the creator's learning than for the user's, consistent with the fact that also more articles focused on learning-related matters for the creator—as shown in the third research question. For the creator, the most frequent explanations refer to active learning, motivational processes, role of ICT, and knowledge building. For the user, the most frequent explanations refer to peer learning, role of ICT, and motivational processes. In both cases, learning by teaching and audience effect are the least frequent explanations.

3.4.1. Active learning

Creator. 163 articles reported explanations referring to active learning for the creator. The main emergent descriptors were: active learning; constructionism; constructivism; learning by doing; experiential learning; learning by design; hands-on tasks; project-based learning; student-centered practices; authentic learning; real-world situations; participation in the community as content creators; flexibility and openness of the tasks; degree of choice and autonomy; self-directedness; sense of responsibility and ownership towards the learning process.

User. 21 articles reported explanations referring to active learning for the user. The main emergent descriptors were: active and participatory role as peer reviewer; self-directedness; sense of responsibility and ownership towards the learning process; experiential learning; student-centered practices.

3.4.2. Audience effect

Creator. 71 articles reported explanations referring to audience effect for the creator. The main emergent descriptors were: peer pressure; heightened engagement due to responsibility towards the audience; thinking about the effect on the audience; the role of anonymity; anticipating misconceptions; revising one's own knowledge.

User. 4 articles reported explanations referring to audience effect for the user. The main emergent descriptors were: potential for the user when the material is created with the user in mind; user considering the audience of user-generated feedback, and the potential effect both on the feedback provider and receiver.

3.4.3. Knowledge building

Creator. 141 articles reported explanations referring to knowledge building for the creator. The main emergent descriptors were: deeper approaches to learning and meaning-making; higher-order thinking; cognitive

elaboration; generative strategies; self-explanation; critical reflection; metacognitive processes; mental activity involved in preparing and communicating content to others; mental activity involved in using various formats and ways of expression—multimodality—; socially shared construction of knowledge—social constructivism—; writing to learn; connection between new and prior knowledge.

User. 28 articles reported explanations referring to knowledge building for the user. The main emergent descriptors were: deep processing and critical evaluation as peer reviewer; surface/deep learning as passive user; peer-mistakes as a source of learning; meaningfulness of peer-generated materials.

3.4.4. Learning by teaching

Creator. 27 articles reported explanations referring to learning by teaching for the creator. The main emergent descriptors were: learning by teaching; learning through teaching; teaching as way of learning; mastering the topic in order to teach it; generating explanations for others; reflection on teaching practice; student-as-teacher; peer-teaching; adopting the teacher's role; writing-to-teach.

User. Only 1 article reported an explanation referring to learning by teaching for the user. The emergent descriptor has to do with learning by generating evaluative comments and piece of advice to someone else's material prior to creating one's own product.

3.4.5. Motivational processes

Creator. 161 articles reported explanations referring to motivational processes for the creator. The main emergent descriptors were: engagement, participation, willingness, volition and interest towards the task or the topic; enjoyment, satisfaction and positive attitudes; perceptions of value and usefulness towards the task or materials; intrinsic and extrinsic motivation; instrumental motivation related to assessment; sense of achievement and confidence; self-determination; self-efficacy; novelty effect; personal preferences; voluntary or compulsory participation; gender-related differences in terms of motivation towards certain areas or kinds of tasks; motivational processes related to ICT, active learning, and audience effect.

User. 43 articles reported explanations referring to motivational processes for the user. The main emergent descriptors were: engagement and willingness towards the task or topic; enjoyment, satisfaction and positive attitudes; perceptions of value and usefulness towards the materials; reduced anxiety and stress thanks to using peer-generated materials for review; instrumental motivation related to assessment and software's rewarding system; students' needs and expectations; novelty effect; entertaining features of the products related to multimedia; sense of achievement and confidence when providing peer feedback.

3.4.6. Peer learning

Creator. 127 articles reported explanations referring to peer learning for the creator. The main emergent descriptors were: boosted learning thanks to collaborative interaction with peers when creating the teaching materials; acknowledging students' diverse skills; learning in social interaction with peers—social constructivism—; the potential of peer-feedback for the material creator; heightened sense of community of learners where everybody feels responsible for others' learning.

User. 68 articles reported explanations referring to peer learning for the user. The main emergent descriptors were: giving feedback to others; the potential for the user to learn from peer-generated materials and to get involved in discussions about the artefacts; potential use and reuse for students from successive courses, both for learning and as models.

3.4.7. Role of ICT

Creator. 143 articles reported explanations referring to the role of ICT for the creator. The main emergent descriptors were: enabling multiple forms of expression—multimodality—; potential for learning beyond the class and home-school connections; potential for having students in the role of content creator; developing multimedia skills; familiarity with tools; software mechanics and flexibility; technical issues; controversy about the

concept of digital natives; digital distraction; digital divide; creating an audience through uploading the material to the internet; fostering social presence; facilitating peer interaction; technology, content and pedagogy; ICT as a motivational factor.

User. 56 articles reported explanations referring to the role of ICT for the user. The main emergent descriptors were: multimedia format enhancing the users' learning; sharing content with others; managing virtual platforms to organize the content; usability and accessibility; familiarity with tools; peer interaction and peer feedback; teaching outside the classroom; integrating students' digital habits.

3.4.8. Scaffolding

Creator. 106 articles reported explanations referring to scaffolding for the creator. The main emergent descriptors were: scaffolding subject-matter knowledge construction; scaffolding the use of tools; sustaining motivation throughout the process; use of models—from the teacher or from peer students—; preparatory assignments; support materials to guide the product creation; task structuring; teacher feedback; peer scaffolding in interaction; student-generated physical objects as scaffolds for reasoning processes; reducing cognitive load.

User. 21 articles reported explanations referring to scaffolding for the user. The main emergent descriptors were: instructions and guidance on how to evaluate materials and elaborate feedback; reducing cognitive load; teachers guiding students during the use of materials; peer-generated materials scaffolding the user's learning.

3.4.9. Time-on-task and practice effect

Creator. 76 articles reported explanations referring to time and practice effect for the creator. The main emergent descriptors were: time-on-task, student engagement and mental effort; iterative tasks in the process of generating the product; repeated cycles of material creation; revisiting content; exposure to technology; the learning curve of the task; time constraints; time efficiency; need for continuity and sustained practice; prior experience with similar tasks.

User. 26 articles reported explanations referring to time and practice effect for the user. The main emergent descriptors were: time-on-task devoted to using peer-generated materials; practice effect of studying from peer-generated materials; revisiting the material and learning at self-set pace; freed-up class time from flipped-classroom use of peer-generated materials.

4. Discussion

The analysis of product types —first research question— showed high diversity, not only between the four groups of products, but also inside each group. This high degree of diversity is in line with prior literature reviews (Gray et al., 2010; Reyna & Meier, 2018a; Snelson, 2018; Winslett, 2014). The four groups of materials identified in this scoping review —audio/visual, questions, texts, and educational games— should not constrain practitioners in the design of interventions based on student-generated teaching materials but serve as a guiding typology showing the wide range of products than can fulfil a teaching function. As evidenced by the two articles that could not be classified in any of these groups (Danish & Enyedy, 2007; Papadopoulos, 2004), the choice of product type has to consider the learning objectives both for its creator and user in every specific context.

As regards sources of information —second research question—, the findings showed four main sources: product creation, use of the product, participants' perceptions, and learning outcomes. Product creation —both process and product analysis— and learner perceptions had been identified in Snelson (2018), and the measure of learning outcomes through grade point average and exam scores in Farrokhnia et al. (2020) and Reyna and Meier (2018a). The findings of this review showed that participants' perceptions are the most frequent information source of studies focusing on student-generated teaching materials. There is a need for triangulating the vast amount of information coming from participants' perceptions with other sources. More emphasis should be placed on them, especially on the use of the product —the new source of information identified in this review. The use of the teaching material is actually very important for the success of interventions based on student-generated teaching materials, not only for the users but also for the students creating the teaching materials. The expectation that someone will eventually use the material for learning is crucial for the learning-by-teaching

potential (Bargh & Schul, 1980; Kobayashi, 2019). If students creating the artefact perceive that their materials are not used by others, subsequent interventions asking them to generate materials might lose the expectancy effect, and its potential for engagement and learning might be reduced.

In reference to learning-related matters —third research question—, the findings showed four themes: subject matter, cross-curricular competencies, academic emotions, and engagement. These results are in line with prior reviews, not only identifying both cognitive and motivational learning outcomes, but also distinguishing between domain-specific knowledge and domain-general skills in the socio-cognitive dimension (Farrokhnia et al., 2020; Gallardo-Williams et al., 2020; Gray et al., 2010; Reyna & Meier, 2018a; Snelson, 2018). As evidenced in the descriptors of the four themes, each of them gathers different specific learning-related matters that are worth of more fine-grained analyses in future reviews. Moreover, further studies will have to address the connections between academic emotions, engagement, and learning achievement (Pekrun & Linnenbrink-Garcia, 2012).

As for researchers' explanations —fourth research question—, the findings showed a wide range of explanations. The most frequent explanations referred to active learning, motivational processes, role of ICT, and knowledge building —for the material creator—, and peer learning, role of ICT, and motivational processes —for the user. The role of ICT and motivational processes emerge as salient explanations both for the material creator and user. With respect to the role of ICT, its spread and development is making a huge impact not only on the amount of accessible information but also on the multiplicity of languages and formats, as well as on the number and diversity of contexts in which people participate (Coll, 2013; Collins & Halverson, 2010). There is a wide range of possibilities of creating and using materials thanks to these multiple alternatives. The use of technology in class can be beneficial when it involves unique affordances that enhance effective learning principles (Yeung et al., 2021).

As for motivational processes, there is plenty of evidence indicating that affect influences cognitive processes that contribute to learning (Pekrun & Linnenbrink-Garcia, 2012). Despite the widely positive results in terms of academic emotions and engagement, the novelty effect of practices based on student-generated teaching materials may decrease. Finding ways to make these practices sustainable in schools is needed.

Two of the approaches that might help in making them sustainable have to do with the two least frequent explanations reported in the articles: learning by teaching and audience effect. The latter is integrated in the learning-by-teaching framework (Duran & Topping, 2017). Even when there is no interaction with the audience, social presence can enhance the effectiveness of learning-by-teaching practices (Hoogerheide et al., 2016; Zajonc, 1966). According to Hoogerheide et al. (2016), being aware of the addressee and perceiving it as real —although not physically present— can generate what is known as productive agency: the belief that our own actions can affect others (Schwartz, 1999). Adopting a learning-by-teaching perspective may contribute to the effective planning and implementation of interventions that have students generate teaching materials. This perspective will allow teachers to anticipate difficulties and boost the potential learning benefits for content creators, as well as for the audience using the material. The endeavor towards a fairer society should consider the role of learning by teaching in educating citizens who can teach and learn with other people, so that knowledge becomes truly democratized (Duran, 2017).

Several limitations should be pointed out to nuance the findings of this review. First, although only peer-reviewed articles were included, the degree of methodological rigor is diverse. Results were not weighted in terms of research quality of the articles. Although scoping reviews do not aim to assess the methodological quality of individual articles (Arksey & O'Malley, 2005), following Daudt et al. (2013) the quality of the studies was considered in the eligibility criteria. However, future systematic reviews will have to assess the validity of each study and consider this when reaching conclusions (Petticrew & Roberts, 2006).

Second, the analysis of interventions only focused on the student-generated products, without considering in detail the specific context of each intervention. Future reviews may not only focus on diversity emerging from the type of product but also from other sources (i.e., product function, addressee, length of intervention, individual or collaborative creation, initial training, support given throughout the intervention, way of sharing the product with the audience, or product assessment). Moreover, systematic reviews and meta-analyses could provide further insights into the effects of creating or using student-generated materials.

Third, the distinction between creator and user of student-generated teaching materials that was adopted in this scoping review may need further consideration. In this kind of practices, according to Contributing Student Pedagogy, the roles of teacher and student become fluid (Hamer et al., 2008). Hence, some possibilities of these practices should be considered: students may become both the creators and users of peer-generated materials; interventions may consider the role of students in peer-assessment practices; students from successive cohorts can use peer-generated materials as learning resources and models.

All in all, student-generated teaching materials is an emerging area of study that has shown potential benefits —and challenges— through a wide range of products across disciplines. Different lines for future research emerge. First, considering that most studies come from higher education, further research is needed in primary and secondary education. Second, future studies should further address the creation and use of student-generated teaching materials in formal sciences and humanities, the two most underrepresented areas in this review. Third, given that there is more information about the material creator rather than the user of student-generated teaching materials, future studies could further focus on the latter. Fourth, in terms of research design, there is a need for randomized controlled trials (Styles & Torgerson, 2018) and quasi-experimental pretest-posttest control-group designs—difference-in-differences designs (Gopalan et al., 2020)—that rigorously assess the effectiveness of interventions and disentangle the effect of creating and using student-generated teaching materials. Mixed methods research such as sequential explanatory design (Creswell, 2015) may offer an interesting approach to shed light on the complex activities involved in the elaboration of teaching materials. Moreover, correlational designs can contribute to the identification of connections between factors involved in these practices, and participatory research designs can help in understanding how to make these practices more sustainable in schools. The intricate relationship between research and practice will have to be considered, both for designing evidence-based interventions (Nelson & Campbell, 2017) and for investigating the implementation of these interventions to contribute to scientific knowledge construction.

5. Availability of data

A summary of data is provided in a separate file (Supplemental online material). This file shows the codification of each article. It is available at: https://doi.org/10.17613/1jfs-m634.

References below are the ones cited throughout the manuscript. References of the articles analyzed in this scoping review are gathered in a separate file, which is available at: https://doi.org/10.17613/xbsy-f944.

6. Funding details

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