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Towards a circular economy of learning environments

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Abstract: In this article, we discuss the status of student productions in learning environments and the ways in which they can be valued as contributions, i.e., reusable resources. Through a review of the literature and case experiences, we characterize the notion of contribution in an educational context. We present a model of the processes and the contexts of their reuse, particularly with respect to the actor's roles and dissemination scope. Our proposition contributes to the implementation of a "circular economy" of learning productions in a context of active pedagogy, mass education, and open education.

1 The status of student productions in mainstream education

Class-based education, whether face-to-face, remote or blended, is often characterized by a double asymmetry: on the one hand, the asymmetry of knowledge, i.e., the teacher or the teaching team has the knowledge to transmit (Park, 2012); on the other, asymmetry of the number of students, i.e., a reduced teaching staff for a large number of learners. Whether we refer to a "traditional" course (presentation of knowledge followed by implementation exercises) or to a more active approach (a learning scenario with teacher guidance), most pedagogies share the following constants:

- The learner remains permanently in an asymmetrical learner role;
- His or her productions serve the sole objective of learning, and once the learning is done, they are discarded;
- The course works mostly in a closed world.

In this article, we would like to question these constants, and in particular the role of student productions that can take many forms: exercises and problems solved, forum messages, collections of resources, construction of cases, presentations, position papers, research papers, designs, etc. Isn't it questionable in terms of cost rationalization in the context of mass teaching that productions are meant to disappear at the end of the course, i.e., become a form of waste? Is there not a contradiction about, on the one hand, the will to train people to contribute to knowledge (Scardamalia & Bereiter, 2003), to build authentic skills, and to be useful (Stokes, 1997) and, on the other hand, to ignore what learners can build and produce ?

Thus, our question is: how can we design training in which student productions allow an individual to learn within a course while participating in the construction of exploitable wealth in a wider scope? Firstly, we will discuss some theoretical contributions and list teaching strategies that already do challenge the above constants, question the permeability of teacher and learner roles and develop the concepts of resource, production, contribution and reuse. We will then present and discuss examples from our own practice. Against this backdrop, we will suggest a framework of sharing and reuse of learner productions.

2 From the notion of production to the notion of reuse

The literature addressing the reuse of student productions in a general and systematic way is not abundant. The notion of the valorization of productions as a resource for existing or future learners is found in the theories of knowledge building (Scardamalia & Bereiter, 2003). In the same vein, *communal constructivism* (Holmes, Tangney, FitzGibbon, Savage, & Mehan, 2001) extends socio-constructivism to the community. Collis & Moonen (2009) use the term contributing student or *contribution-oriented pedagogy* to refer to a set of reuse practices for student productions: "An approach to learning in which students regularly contribute material, where they are found, or adapted to a common web environment, where the contributions are assessed and where the contributions are further developed by other students in further learning activities." (Collis & Moonen, 2009:445-6). New sharing cultures are beginning to leave an imprint on the educational system. For example, the "making" movement defines the role of prosumer (Miño-

Puigcercós, Domingo-Coscollola, & Sancho-Gil, 2018), someone who uses artifacts produced by others, but also produces some. Critical prosuming is also seen as the major challenge for new media literacy (Lin, Li, Deng, & Lee, 2013) and therefore part of 21th century skills that each program should foster. In computing education, repositories like GitHub and hackathon-like events favor a culture of sharing, cross-fertilization and reuse (Zagalsky, Feliciano, Storey, Zhao, & Wang, 2015). Finally, the "learning object" movement tied to standardization of e-learning content addresses reusing and remixing of resources by other agents (not learners) (Wiley, 2002). Of interest to us are debates about reusability, accessibility, granularity, adaptability and transferability to other contexts, educational annotations, and sequencing. Probably, most learner-produced resources usually fall into either Wiley's "fundamental" (simple assets) or "combined open category" (online composite documents), but as our experience shows students also can contribute to other categories. In the same vein, we suggest that learner productions can become resources for different types of learning, e.g., Fowler and Mayes' conceptualization, construction and integration, cited by Littlejohn, Falconer, & Mcgill (2008).

2.1 Instructional Strategies Extending Learner Roles and Contributions

We now discuss some learning strategies that assign students a role that can go beyond that of learner-consumer, valorizing productions produced during training, or implementing a more global learner contribution approach.

Project-based learning. This pedagogical strategy consists of developing skills and knowledge through the conducting of a concrete project (Moursund, 1999), sometimes valued beyond the spatiotemporal scope of the class. For example, in animation schools, animation films made by students participate in competitions and are regularly awarded prizes. Another example is the internship in engineering schools that can lead to a deployed product. Thus, the work of the learner does not remain in the state of "exercise as part of an apprenticeship", but becomes a genuine knowledge production activity, valued outside of class.

Learning by teaching. In teaching, the student - as an individual - consolidates his/her knowledge and learns, while at the level of the class, his/her interlocutors learn as they would with a teacher (Gartner, Kohler, & Riessman, 1971). We can also mention the "école mutuelle" and the Lancaster model, which were developed in France and Great Britain in the 18th century (Lesage, 1975). A large class, sometimes hundreds of students, is managed by a single teacher assisted by a principal monitor. Children of the same development level are supervised by a student monitor. Such groups work either with a written support in a bench that can accommodate 16-18 students, or orally in a semicircle in front of a board.

Peer review. This strategy, invented as collaborative learning strategy to enhance metacognition (Topping, 1998) and popularized within the framework of the MOOCs for economic reasons, consists in scripting the evaluation of learners by other learners (Reinholz, 2016). That type of contribution is less about reusable content, but it shows a way to change or even reverse the roles between teachers and learners. Its efficiency is certainly to be weighed by the inherent difficulties related to this inversion and requires, upstream, an in-depth design work in order to equip the learners correctly (for example by providing them with an evaluation grid) and to train them for this evaluator role.

Knowledge building. This approach, developed by the "Toronto School", aims to reorganize the roles of the classroom learning situation by viewing the learner as a person who can contribute to a knowledge base that is itself accessible outside the classroom (Scardamalia & Bereiter, 1994). This model brings the class situation closer to the situation of a scientific community. Through a peer evaluation mechanism, learners build together a corpus of knowledge in a software environment called "knowledge forum". The focus is on collaborative co-construction, made possible by technology. A similar approach is put forward in various community of practice theories and models (Lave & Wenger, 1991).

cMOOC. A more recent variant of the "Toronto" model, based on "connectivism" (Siemens, 2005), was formulated for the design of the first MOOCs, now called cMOOCs. Their connectivist pedagogy identifies three types of learning activities: 1) collective constitution of a wide variety of resources; 2) after a meaning-making process, learners create artifacts using an open online tool; 3) sharing productions with other members of the course and the wider audience. Participation in these activities is considered essential for learning.

Learning through public writing. *Writing-to-learn* refers to a family of pedagogical design models postulating the positive effects of pedagogical scenarios involving learners in writing activities. Writing can encourage the organization and transformation of acquired knowledge (Flower & Hayes, 2016), as well as the creation of new knowledge (Galbraith, 2009). Public writing, for example in Wikipedia (Brailas, Koskinas, Dafermos, & Alexias, 2015) adds a structuring element through editing rules and interaction with a wider community and can increase both the quality of productions and the learning effects. Writing in a smaller public wiki may at least have the effect of stimulating quality considerations (Guth, 2007).

These pedagogical models convey certain common assumptions. Most share the ideas that a learner can directly or indirectly help others and/or contribute to common knowledge, and that the activity of producing reusable objects has a positive influence on the learner's knowledge and skills.

2.2 The notions of resource, production and contribution

Reusable resources in the educational technology literature mostly refer to either simple assets or so-called learning objects, both of which can be assembled into larger collections, e.g., a reusable course (Spector, 2012:13). Certain types of resources, including metadata and sequenced learning content have been formalized to facilitate dissemination and reuse through standardized file archives that can be deployed in learning management systems. These are mostly based on the IMS Content Packaging framework (Ochoa & Ternier, 2017). In a more general sense, a resource can be defined as any entity (digital or not) used in a teaching and learning process. They are inputs into the learner or teacher activity.

Student productions are not part of these schemes, since they are only considered an output from activities. Most of the learning literature is focused on the way students learn through the production process (for training, for collaborating, for memorizing, etc.). Output of the activity is used in some summative or formative evaluation, then thrown away. Positioning a learner production as contribution and learning resource requires redefining the traditional view of (reusable) learning resources.

If a contribution is always the result of a production of a learner or group of learners, each production is, however, not a contribution, which is tied to the notion of sharing with others. We can characterize the contribution by three components: uniqueness, quality and purpose. Thus, a student contribution will be unique, its quality exceeds a certain quality threshold (often arbitrary) and its purpose is to interest a certain public. Quality assessment will often be made by teachers, but not exclusively. Knowledge co-construction schools of thought are characterized by virtually zero moderation and if there is moderation, it is operated more spontaneously by various actors.

2.3 Contributions as reusable resources

Valorizing learners' productions requires a set of activities involving several roles and processes. The producer, usually the learner, starts with inputs (resources, instructions, observations) to create productions; the reviewer, usually a teacher, evaluates the productions; the disseminator (or publisher), sometimes depending on evaluation, ensures the distribution of the contributions to one or more audiences likely to be interested; the beneficiary uses the contribution for its own benefit. Valorization processes can be organized in many ways, often actors accumulate several roles. For example, Wikipedia, which is often used as a resource in educational contexts, has developed a system of rules and practices that frame a cyclical process of producing articles in which the same actor is producer, reviewer and publisher. Other approaches will see the teacher both evaluate and decide on the accessibility of the content, i.e., take the role of moderator, a hybrid role of reviewer/evaluator and publisher.

The production process leading to original productions can rely on multiple proven educational strategies, many of which have been mentioned above. But the evaluation and diffusion process include a number of difficulties. If it relies, classically, on the teaching team, scaling becomes difficult. A course of 100 students producing 10 productions each, totals to 1000 productions to evaluate. The dissemination process is based on the logic of communication, which does not necessarily fall within the field of competence of teachers. It can also be perceived as an additional task, adding to the burden of teaching tasks. Among the possible solutions, the institution could provide resources for dissemination, e.g., through its outreach services. The two alternatives to this approach, namely peer review and automation of evaluation, raise other organizational and ethical issues.

In terms of expected benefits, the reuse of learning contributions can be analyzed from two points of view: (a) value for the learner: increased motivation and commitment through authentic work, useful to others; (b) general value from an ecological point of view: global optimization process, non-destruction of a potentially useful production to others. Finally, any dissemination process involves ethical and legal considerations that should be addressed both at the level of the class and the institution.

3 Experience reports

In this section, we would like to present and discuss examples of courses taught by the authors that, to varying degrees, reuse student productions. At the time of their creation, some courses were not conceived to value learner productions, but resource constraints gradually led their designers to reuse student productions, and to gradually integrate elements of educational designs that today we retrospectively analyze as part of a circular economy of student productions.

Other courses have from the start adopted a public wiki model in which production, contribution and resource are superimposed. We will discuss five Master level courses taught in blended mode, about three days of face-to-face teaching per semester with about twenty learners, equivalent to six ECTS credits (~150 hours of student work) and one MOOC. Both previous discussion and review of these cases will allow us to formulate a framework model for the reuse of learner productions (Part 4). After a brief presentation of the objectives of each course, we will examine in more detail how student productions are reused and valued: internal reuse concerns reuse in the same class or in a subsequent cohort, external reuse concerns sharing with a wider audience.

3.1 The VIP course

"VIP" is a course on serious game design and development. A first part includes classical teaching (lessons + exercises such as the analysis of an existing game) and in a second part learners design and implement an educational video game. Reuse lines have gradually been put in place over the years:

Internal reuse: the development of video games requires a certain number of resources, which are now the subject of an intercohort internal reuse: (1) Help (tutorials, tips and tricks, links) for using authoring tools is written by the learners on wiki pages, to be used by the learners of the following cohorts. (2) A list of links to sites containing royalty-free images and sounds is available on a wiki page, spontaneously created by a learner. Today, all course actors are encouraged to add media sources to this page. (3) Each year, teachers must consider a dozen new games for analysis and maintain large list for this, open to learners. All the actors of the course or even beyond (teachers, learners, former learners, teachers' colleagues) can add a game that they consider potentially relevant for analysis. Student participation is not mandatory, but it is quite possible to do so, in particular by asking that the games identified during a literature review that is part of the project approach, be included in this list.

External reuse: Games are developed in response to requests from external sponsors. Thus, students are more motivated, because their production, if successful, is used by the sponsor. In addition, the teaching team describes successful games in a showcase site (https://tecfa.unige.ch/jeux/jeux/), a motivating diffusion process for the learner, but also for the teaching staff, who can better communicate on the content of the proposed master. More recently, institutional support has made it possible to improve the games produced (for example by adding a uniform home screen or by correcting certain bugs), and to communicate more generally about the existence of the site. Finally, a traditional activity of synthesizing a research article from the serious game design literature was replaced by an activity of adding an entry to a publicly available annotated bibliography about serious game.

Other productions of the course progressively follow this approach, and since this year, the teaching team has systematized the cyclical approach, seeking that each production can become resource.

3.2 The BASES course

The BASES course on psychological and educational foundations of educational technology uses a public wiki (http://edutechwiki.unige.ch/fr) and aims from the outset to create reusable resources for the same class, for other cohorts and for the general public. So we neither distinguish between production and resource, nor between validated and non-validated content. The course aims to familiarize participants with important theories of learning and teaching through the analysis and production of screen casts based on concept maps, and production of a MOOC module. It is designed as a collaborative self-study course, without tutoring. The course has been developed in three phases and has evolved over time. In a first edition, students were asked to create three screen casts and to assist in the creation of six other screen casts. In a recent edition, students engage in three activities: (1) evaluate 18 screen casts with a multiple-choice evaluation grid which they first had to build together; (2) produce, in several stages, a concept map explained by a screen cast on a specific subject related to a wiki article, assisted by two peers who give structured feedback (technical quality, comprehension, academic quality, etc.) for each version; (3) participate in the construction of a MOOC module from resources (texts, concept maps, and screen casts) already produced in the wiki.

Internal reuse: Participants first learn by consuming resources (texts, concept maps and screen casts) produced by students from other cohorts and by peer evaluation. Then they learn by producing new concept maps and screen casts and through peer tutoring. Creating a MOOC module allows consolidating knowledge about a domain and about educational sequencing. These modules are not mature and not deployed, but serve as examples for subsequent promotions.

External reuse: Wiki productions (concept maps, peer evaluations and screen casts) are public and the final screen casts are highlighted in the wiki article that deals with the subject area.

3.3 The STIC I course

STIC I aims to introduce principles of computational thinking and programing through the design, development and deployment of small web-based applications. On the technical side, this includes an introduction to interactive web page design and JavaScript programming. Learners have to create six mini-projects with increasing technical difficulty. Syllabus, instructions, online help and learning materials (except detailed code) are published in EduTechWiki (http://edutechwiki.unige.ch/fr). For each project, students study a part of the wiki-based online manual and explore online example code available on GitHub. They also have to contribute to the wiki (10% of the grade).
Internal reuse: teacher-produced text tutorials are improved (mostly through small fixes, e.g., grammar), wiki forum discussions help clarify instructions and other questions. Overall, student participation help to increase both tutorial contents and learning design.

External reuse: Both the online textbook and additional contributions related to students' interests and projects enhance wiki contents and are open to a large public.

3.4 The STIC III/IV course

The STIC III/IV courses focus on computer-aided design and manufacturing ("making") in education (https://edutechwiki.unige.ch/fr/CFAO). The theme of the course changes every year. Past topics included "creation of teaching materials with laser cutting", "creation of constructive tools with a 3D printer" or "create embroidering to initiate change". Participants first learn about technologies by creating small shared objects for a common "theme", e.g., badges representing their persona in an embroidery class. They contribute to the writing of wiki textbooks, and the organization of a public event. They conduct a project that must involve third parties, also documented in the wiki. Everything (technical manual, foundations, wake-up activity designs, project paper and project design) is distributed as a virtual book, printable on request and distributed during outreach events, e.g., during a book fair.

Internal reuse: The technical part of the environment is designed in a writing-to-learn spirit, but many pages are composed after an activity or even towards the end of the course and are therefore relatively unhelpful to participants of the same cohort who have already almost completed their project. The pages produced are subsequently revised by a paid learner and the teacher and are integrated into a navigation system and the virtual print-on-demand book. The material is then used in new courses, allowing covering more manufacturing technologies than in previous editions. Materials are also used for shorter training classes.

External reuse: Digital models and textbooks produced by students are used around the world by a few thousand users.

3.5 The qualitative research methodology course

This course is taught with an authentic research project: students take up the role of novice researchers and the overall goal is to learn while creating reusable knowledge (Wagner, Garner, & Kawulich, 2011). Four main objectives guide the course: 1) identify the characteristics of qualitative research and explain the research cycle; 2) critically read and evaluate the quality of a published qualitative article; 3) analyze semi-structured interviews; and 4) answer a research question with a structured scientific report based on data. To meet the first objective, students have to read extracts from methodology books and produce summaries on topics provided by the teacher. Each individual student has to write an academic summary of 300 words on one of the 21 topics addressing the basics of qualitative research) on a Moodle wiki, allowing the entire cohort to have an overview on each of the 21 topics. Summaries are reused for transversal internal reuse with the next cohort of students who is in charge of evaluating them applying specific rubric. Objectives (2) to (4) are geared towards the main contribution which takes the form of a published article. Upfront, the teacher produces the theoretical and methodological parts of the article, conducts interviews and provides students with both the work in progress article and the data.

Students work in groups and each group is accountable for producing the answer to one of the research questions. To reach this goal, they analyze interviews and write up their research report, using creative ways of presenting data analysis (e.g., visualizations; matrices) and interpretation. In the end, each group of students adds the part concerning his/her research question in the results section. The methodology section is also revised, particularly specifying limits of the study. Finally, students evaluate the entire article using criteria of a qualitative research article. The teacher rereads the entire article, checks that it is coherent and sends it to the previously identified conference or journal for authentic external evaluation. If the article gets accepted, it becomes a contribution in a public way and is available for external reuse. Qualitative methodology lends itself particularly well to a circular economy model

because of its iterative nature. Gradually, cohort after cohort, a more complete image of the research object is being built.

3.6 The MOOC "Contact Kit in Oriental Languages: Chinese"

The introductory Chinese MOOC "Kit de contact en langue orientale : Chinois (Contact Kit in Oriental Languages: Chinese)", hosted on the French MOOC platform FUN (France Université Numérique, France Digital University), aims to support French-speaking learners in an initiation to the Chinese language and to facilitate a first discovery of the Chinese cultural universe. The MOOC was launched three times (2017, 2018 and 2019) and welcomed around 26,000 learners in total. The MOOC lasts seven weeks, with one introductory week and six weeks of training, as well as a progressively graded daily work program. To strengthen the cultural dimension, 6 cultural forums were opened, including specific questions in relation to cultural elements discussed weekly. A tutoring has been set up. This MOOC values learners' productions in culture forums in two internal ways: (a) use of the "pin" tool to make contributions validated by teachers / tutors more visible in each forum; (b) creation of a MOOC resource unit to bring these contributions together to make them more visible to all participants.

In the 1st session, in these 6 culture forums, more than 3386 discussion threads were created by the active learners (learners who actually started the course by validating at least one exercise). The most active thread "Lesson of Chinese civilization" has attracted 53 contributors. To value the contributions, the tutors use the tool "pin" to put them at the head of the discussion. In addition, it has been noticed that there is a small group of learners who are very active in forums. Not only do they contribute to the discussion but also they answer questions from other learners. This observation led the teaching team to reflect on the value of their contributions in order to motivate learners and make learning more dynamic.

In the 2nd and the 3rd session, more than 5700 threads were created by active learners. To make visible their contributions, the tutors used as before the "pin" tool. In addition, a "cultural" resource unit has been created within the MOOC resource center, accessible to all participants. The corresponding contributions have been categorized and reorganized into cultural themes and sub-themes.

Thus, the learners' contributions are valued not only at the level of the learning activities (here the forums), but also at the level of the whole MOOC (the resource center). Through the teacher moderation process, the valuable contributions are categorized and reused as recommended resources for all learners. In the context of the MOOC, the internal reuse takes on a whole new meaning, as many learners engage in little or no activity and remain observers (Rieber, 2017) (Shrader, Wu, Owens, & Ana, 2016) . Thus, the contribution to the resource center above can already be considered as an external reuse (restricted, see Section 4). For example, Chinese teachers follow this MOOC, and the resources built by the learners can be used in their teaching.

3.7 Overview

Most learner productions in the described courses became public resources. For public production and dissemination we either used EduTechWiki (which has about 1.5 million users / year and each addition consolidates relative popularity of a given topic area) or smaller, specialized web sites in order to achieve targeted visibility (e.g., to advertise the list of created educational videogames, or artifacts in a "making" class).

With respect to our wiki experiences, we note that involving students in writing reusable materials is interesting and effective, despite resistance to contribute. Resistance to contribute is very high if wiki writing is an accessory activity, according to observations made in the STIC I class. Resistance to contribute is low if the writing activity is clear and focused, e.g., evaluate software or document projects. Let us recall that we pursue both an educational and an economic objective. Writing not only increases the quality of learning, but also makes it possible to create online materials, such as textbooks or collections of case descriptions at very low cost. The production of virtual, printable, books was positively received by the participants and also made it possible to promote resources and themes outside, e.g., in international book fairs and science festivals. Beyond such extrinsic motivation, some students were also intrinsically motivated to produce shared artifacts (screen casts, usable digital designs and books) since they make learning activities more meaningful.

Table 1 includes a summary of various student productions that are reused as resources. Most items are found in column one, meaning that productions are reused inside a class, inside a cohort, and shared with the “world”.

Our experience also reflects that, as teachers and Internet users, we use our own technical infrastructure and never a so-called learning object repository (LOR). This reflects research findings, e.g. “although LORs seem to be a good idea, they are not generally perceived as useful" (Ochoa & Ternier, 2017). The same authors then also point out

that some newer developments can be useful and are being used, probably because they use a simpler design and feature direct use.

Reusing productions	Internal and external	Internal	Transversal internal	External (dissemination)
VIP (serious gaming)	Case analysis, technical information & tutorials		Authoring tools tutorials	Serious Games, annotated bibliography, project descriptions
BASES (edtech foundations)	Concept maps, screen casts, revisions of wiki contents		Peer evaluations, MOOC modules	
STIC-I (computational thinking)	Improvements to online textbooks, Other wiki contributions (technical and conceptual)		Projects (interactive web sites) and reports	
STIC-III/IV (making)	Technical information, "wake-up" activity designs, project designs, project reports			Pediapress books
Qualitative method	Wiki pages on methodological issues	Intermediate results	Academic summaries	Research results (article)
"Kit" MOOC (Chinese)		User contributions in forums		

Table 1: Overview of reusable learner productions

From both the short literature review and our experience described above, we now would like to describe a tentative reuse frame for student productions.

4 Proposal for a reuse model for student productions

From the above, we can propose a sharing and reuse framework for learner productions (Fig. 1) representing the dynamics of the processes surrounding the creation and transformation of learner productions. In this model, a production is characterized by content, evaluation and visibility. The evaluation can be used to improve production (loopback on the producer), but also to trigger a dissemination procedure. The latter changes the visibility of the content. In a context of moderation, the disseminator will make the content accessible to others, giving it the status of contribution. In other contexts, even if the content is already accessible, larger dissemination actions may be decided according to the estimated quality of production. Finally, the beneficiary will be able to benefit from the contribution, especially as its visibility will be high. In a dynamic setting like a public wiki, content, evaluation and visibility are to be understood as processes that grow over time. e.g., in the beginning content is small, there is no evaluation and visibility in search engines is low.

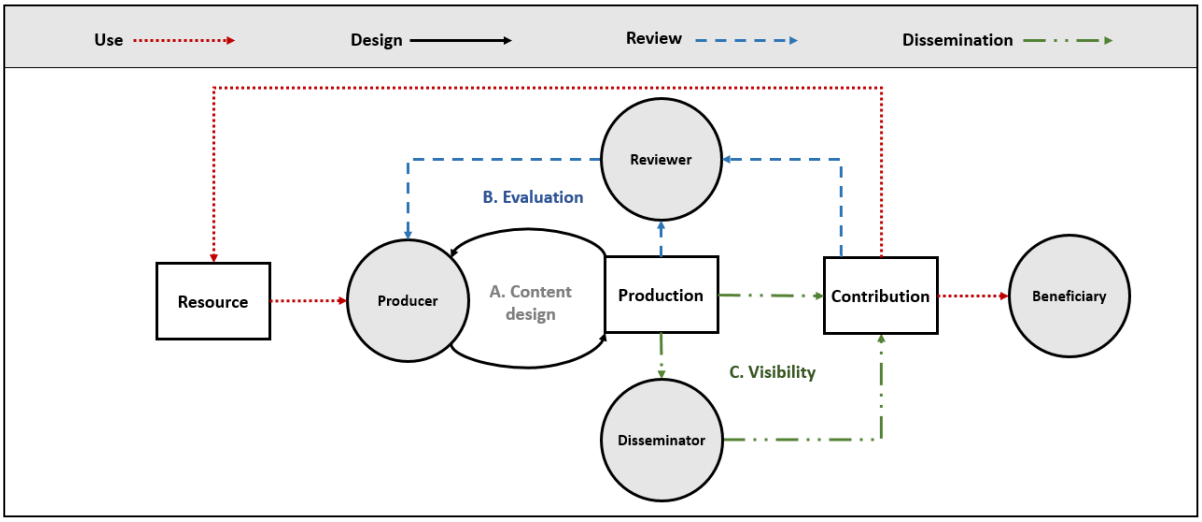

Fig. 1 . sharing and reuse framework for learner productions

Producer, reviewer, beneficiary and disseminator are roles. Each role can be assumed by a same or different actors. Therefore, from a use case perspective, i.e. a description of how users interact with a system, we can present the model in the following way (Fig 2.).

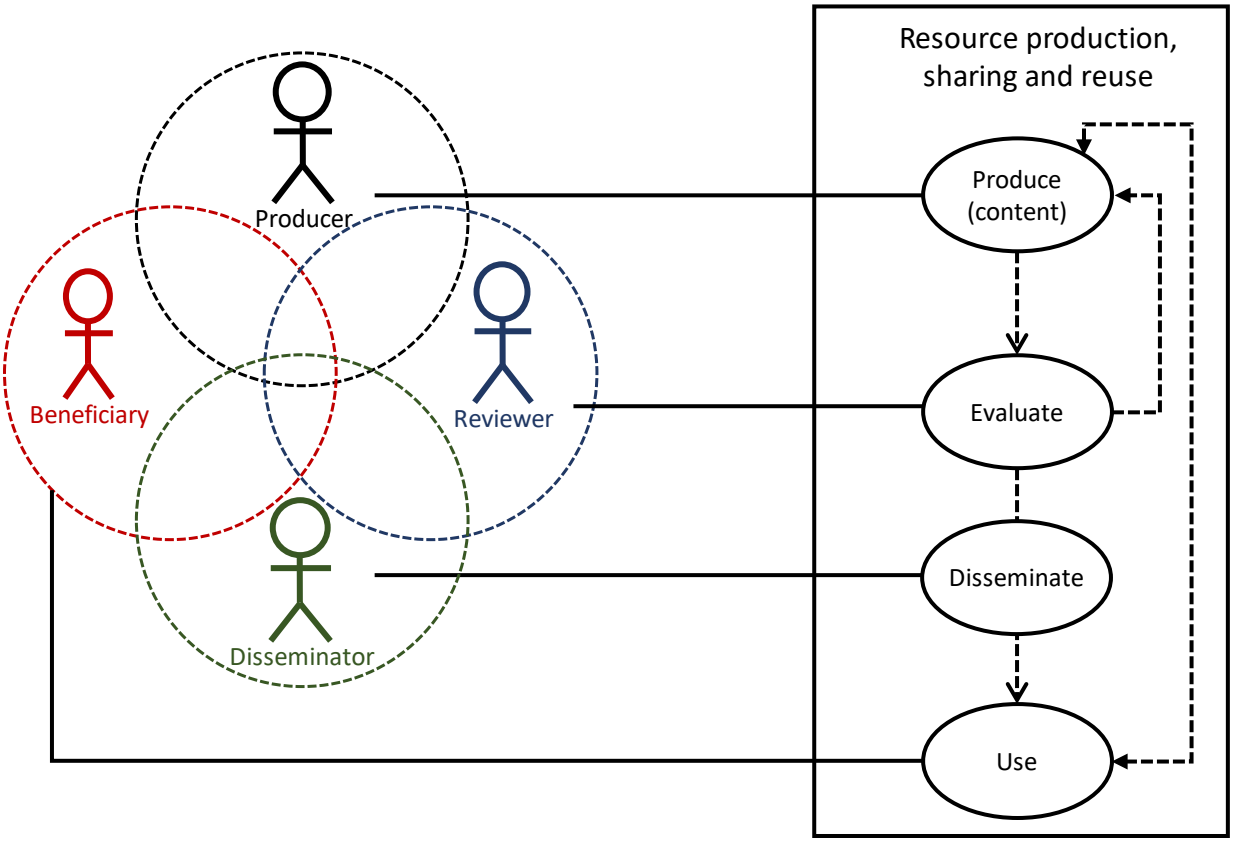

Fig. 2 . Use case diagram - sharing and reuse framework for learner productions

This framework thus makes it possible to define various use cases. For example, a first linear approach consists of a workflow successively transforming input into productions, productions into evaluated and validated productions and finally the latter into actually accessible contributions. On the contrary, in a more open and dynamic approach, students will directly enter into an activity of contribution without moderation, a task that could be carried out by Internet users out of the particular training context. That type of contribution will also be improved in stages, some more or less formalized in the educational design. These contributions will typically be made on web-based software hosting services such as GitHub or in a public wiki, including Wikipedia. In that context, learners can assume all four roles.

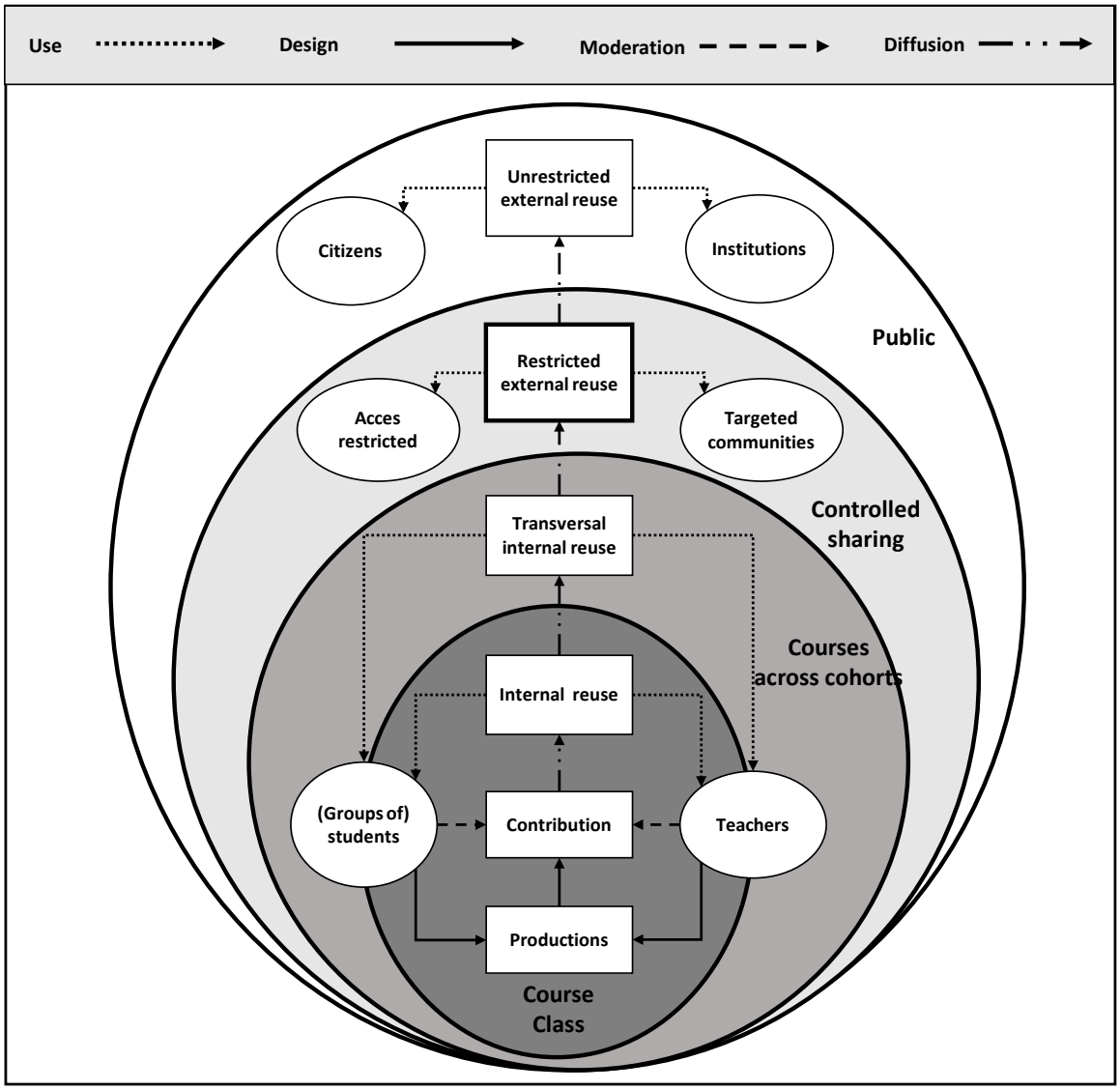

Fig. 3: Model of different diffusion levels of contributions.

A contribution can be associated with different dissemination spaces. Contributing does not necessarily mean broadcasting to a wide audience, but may consist of remaining within the framework of a given teaching, for example. It is thus possible to associate each contribution with an internal, internal transversal, external restricted or external public reuse space (Fig. 3; Table 1). In addition, contents and components can be dynamic (internal and/or external users can change existing content) or remixable (internal and/or external users can copy and remix contents).

An internal reuse consists in sharing each production with the whole class in order to contribute to a common activity or knowledge. An example would be parameters to be set for a laser cutter or a collective list of interesting web page designs according to a common list of features.

The transversal internal reuse exploits the contributions of previous cohorts in a new class. An example is to learn the use of an authoring tool by writing tutorials and examples of applications that can be used in teaching a subsequent class.

Restricted external valorization consists in opening in a controlled way the learning productions to an identified community (ex: collaboration between a diploma of an art school and a diploma of a computer school around student projects) or to diffuse productions on demand, in protected access.

Finally, the last level is to contribute in a public way, for example by publishing certain productions, to make students contribute to a public wiki or a public databank or a deposit like GitHub. There exist many publishing options, e.g., teacher owned or institutional web services, social software, learning object and OER repositories. As we mentioned above, some learning designs engage students to work in the “open” from the start.

5 Conclusion

In this contribution, we identified the need to address and systematize the reuse of student productions. Their valorization is justified according to three axes. The use of reusable productions makes it possible to set up active pedagogies, can enhance motivation, and can reduce the cost of teaching.

At the pedagogical level, while "producing" itself promotes learning (Flower & Hayes, 2016) and the effects of tutoring and peer instruction are well documented in the literature (Topping, 1996), our experiences described in the case descriptions illustrate that producing in the perspective of contributing has a positive effect on the quality of productions and a positive effect on motivation. The valorization of the productions is thus an educational component to be taken into account within the design of learning environments and scenarios.

Through the scenarios that we have cited in this article, reuse seems to depend on processes of production, evaluation, dissemination and use that are identifiable and can be modeled (i.e. a kind of knowledge management). For teachers, it is therefore a question of designing a learning environment that allows the development of targeted knowledge and skills through unique productions while setting up a contribution evaluation system for its dissemination. For learners, it is usually about taking an active role as a responsible individual at the crossroads of the creator and the critical user, and sometimes the evaluator and the disseminator.

The various possible scenarios highlight that reuse cannot be described with a single model, but can be declined in different diffusion and use spaces, in short or long time, within various pedagogical strategies. We may look at the valorization of student contributions within a more global view as a circular economy of production, but we can also observe it as an integrated component in various existing teaching practices. When the productions are reused in a same course, in multiple cohorts or by other institutions, reuse has an economic interest. It can even support the massification of certain lessons or large scale teaching approaches (e.g. MOOCs). In this, the general approach proposed, in analogy with ecology, is part of a circular economy approach that aims to reduce "waste" by maximizing their reuse. This circular approach is still formalized in a tentative and largely experiential way. We hope to have provided a theoretical contribution to its understanding by specifying the notion of reuse of contributions through a characterization of its essential components and its implementation processes. This is a first attempt that will require additional work, both empirically and with respect to the literature on reusable learning objects.

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