# Practice and impact of the instruments in the "applied arts" curriculum

## The case of the French high schools

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*Activities involving Design and Applied Arts (DAA) appear on the curriculum for each cycle from primary to secondary school in France. At primary school (3–11 years) and secondary school (for 12–15 years), these activities are prescribed in the context of two disciplines: at primary, arts education and sciences and technology education; visual arts and technology at secondary. Later (for 15–18 years old) DAA becomes a discipline per se. DAA is taught in a discipline called "Sciences Technology Design Applied Arts" (STD2A). The STD2A curriculum provides multidisciplinary approaches and practice shifts based on design projects involving processes of acquisition of skills. This syllabus does not train design professionals, but educates students about design abilities. This syllabus allows a continuation of study in the DAA in specialised schools and at university (architecture, graphic arts, industrial arts…). This paper proposes to itemise the relationship between design task and design activity within a curriculum of study (the research context) and an activity analysis of the students. Three teaching-learning-design situations have been investigated (different teaching situations and projects of teaching teams) during the summative test in the senior year. The research goal is focused on the instruments the students use to structure their activity and how and why they use them to hone the skills they actually implement in their learning.*

Keywords: multidisciplinary learning environment, teaching-learning process, design skill, instrument, activity theory

## Introduction

### *The research context*

Social practices in design covers specific activities and the areas of application are multiple (urban design, product design, packaging, signage...). The word design in France is often misinterpreted. For the public, it is a skin, a look, a style. For designers, design activity penetrates and includes philosophy of products and institutions that produce them; it is similar to that of engineers. In France, the activity of designers for a long time was separated from engineers' activity. It is only since the establishment of systems engineering in large companies in the 2000s that designers' activity was associated with that of engineers. That is not the case in the Anglo-Saxon countries where design activities are associated with engineering activities.

In education, the teaching of design and Applied Arts (DAA) is stretched between two historical affiliations: arts and industry. It refers to a constructivist approach to knowledge, namely a practical teaching-learning situation that may generate questions from which students will build knowledge. DAA appears on the curriculum for each cycle from primary to secondary school in France. At primary school (3–11 years) and secondary school (for 12–15 years), these activities are prescribed in the context of two disciplines: at primary, arts education and sciences and technology education; visual arts and technology at secondary. Later (for 15–18 years old) DAA becomes a discipline per se. DAA is taught in a discipline called "Sciences Technology Design Applied Arts" (STD2A). The STD2A curriculum provides multidisciplinary approaches and practice shifts based on design projects involving processes

of acquisition of skills. The specific approach in arts is neither that of the practitioner nor that of the historian but that which transverses disciplines to encompass a set of approaches under a common question (Gaillot, 1997). The specific approach in engineering consists of finding and developing solutions according to commercial specifications. Practical teaching-learning situations allow the implementation of appropriation modalities of representation and communication means placed in terms of objects and problems of a technical nature (Ginestié, 2008, 2009).

The STD2A national curriculum is organized over three years of secondary school. The first year, students are sensitized to Design and Arts and Crafts (on average: 6 hours per week). At the end of the 1st year, students choose to pursue or not, this specialty. The 2nd year, students who choose STD2A have 14 hours per week specialised in DAA; the 3rd years students have 18 hours per week specialised. Four or five Applied Arts teachers are required to train students in 2nd and 3rd year. The other thirteen hours per week are split between Sciences and Humanities (MEN, 2011).

This paper proposes to itemize the relationship between design task and design activity within a curriculum of study (the research context) and an activity analysis of the students. The aim is to analyse fundamental learnings of design; built on cognitive, operating and postural knowledge. In this way, Albero and Brassac (2013) enhanced the significance of a pragmatic approach of knowledge acquisition: knowledge individual processes are not apart from social, political, economic environments.

### *The STD2A requirement*

The STD2A curriculum was created in 1981 and was twice transformed and rewritten (MEN, 1981, 1997, 2011). Since 2011, the curriculum refers to professional design activities to stimulate teaching-learning processes and situations, which consider both DAA knowledge and general educational purposes. For instance, professional practices and knowledge are considered within mixed interactions (MEN, 2011, p. 1): general culture, art, and technology; creativity (stimulated by technical, economic and social environments in the traditional and industrial settings); dialogue with other disciplines (engineers, sociologists, economists, commercial, technical); investigation of materials, forms, techniques, systems, functions, needs, sustainable development; control of drawing and illustration tools; constant search for innovation; logical, inquiring mind; and training of an assumed citizen.

Multidisciplinary approach and new development of teaching time were up to the choice of the pedagogic teams. Teaching and learning situations are embedded in methodological approaches with specific and complementary knowledge developed in each clusters of DAA (Creative Approach, Visual Arts' Practices, Technologies and Story of Arts, Techniques and Civilizations). All those clusters are merged by a transversal clusters (Tools and Methods) in which Sciences and Humanities must take part (MEN, 2011, pp. 2–3). This requirement disturbs the previous and main French educational curriculum, partitions it into separate disciplines and so, weakens the "school of rational orientation" (Jackson, 1992). STD2A curriculum gets close to the "cognitive orientation" in which Jackson (1992) considers instrumental and transferable knowledge: teachers need to think about their teaching practices in a dynamic and contextualized perspective, including all the subject matters.

The STD2A national curriculum requests the same common operational objective at the end of the cycle: the implement of a summative multidisciplinary project as a compulsory assessment. It's a project-based-learning (PBL) that causes a significant increase in informal knowledge and a positive change in learners' attitude (Mioduser & Betzer, 2007). PBL needs a specific pedagogical organization. In this way, each high school and each staff of AA teachers with Sciences and Humanities teachers organise their multidisciplinary projects.

The context of this study is the summative multidisciplinary project in which a design activity has been looked at to observe the relationship between design task (the instruments the teachers use to structure their teaching framework) and design activity (how and why the students use them). This paper is focused on understanding the role of instruments in design learning activity when designing is not the main purpose (the students are teenagers).

## Design activity in pedagogical situations

Design activity is examined in a design-learning context as a "construction of representations" (Visser, 2009). First, this perspective is based on the activity theory (Engeström, 2001) and the constructivist approach of knowledge acquisition (Vygotsky, 1978). The activity is also examined through the instruments used by stakeholders in the design field within a reflective practice (Schön, 1983).

### *Design task and design activity*

The design activity is not seen as an activity reducible to a single and permanent coding of actions and operations. Dorst and Cross (2001), Lebahar (2001, 2006, 2007) analysed design activity in order to learn all the features and all the components. Design activity consists of organizing tasks to design an artefact model which does not proceed from an existing model (Lebahar, 2007). Dorst defines it as a co-evolution of the problem space and the solution space, "the two-notional design space":

> Creative design seems more to be a matter of developing and refining together both the formulation of a problem and ideas for a solution, with constant iteration of analysis, synthesis, and evaluation processes between the two-notional design "space" – problem space and solution space (Dorst, 2006, p. 10).

This task appears more as composed of several problems, multifaceted and multidomain (Lebahar, 2007). The design activity is based on situations, representations and task. It closely intertwines several types of interactions and representations (mental images, operative pictures) whose roles vary during the task and the purpose of which is to conduct a programmed guidance.

### *The instrumented activity of the designer: situation of complex interactions*

The design activity of architects, designers and design students has been thoroughly analysed by Lebahar (2007) and Tortochot (2012, 2013, 2015). A portrait has been illustrated within the situation of complex interactions (figure 1), where the designer is a psychological subject interacting with design tasks that organize the changing representations of artefact models to reduce design uncertainties (2), such as from doubtful sketches to accurate 3D models (prototypes, CAD, etc.). Sometimes, other subjects directly interact with different representation states or steps (step 2, twice); for example, in a design learning framework, design teachers separately assess the student's work by considering verbal or no-verbal statements that shape the written, graphic or schematic design outcomes.

Besides, the designer speaks with himself/herself to create decisions about his/her design activity (1). This takes place within the designer's consciousness. To define consciousness, Vygotsky speaks about "experiences just like experiences that are simply experiences of objects" (1997, pp. 71–72). In Lebahar's (2007) study, consciousness is a "cognitive split" that sequentially allows the tasks to be planned in a working context.

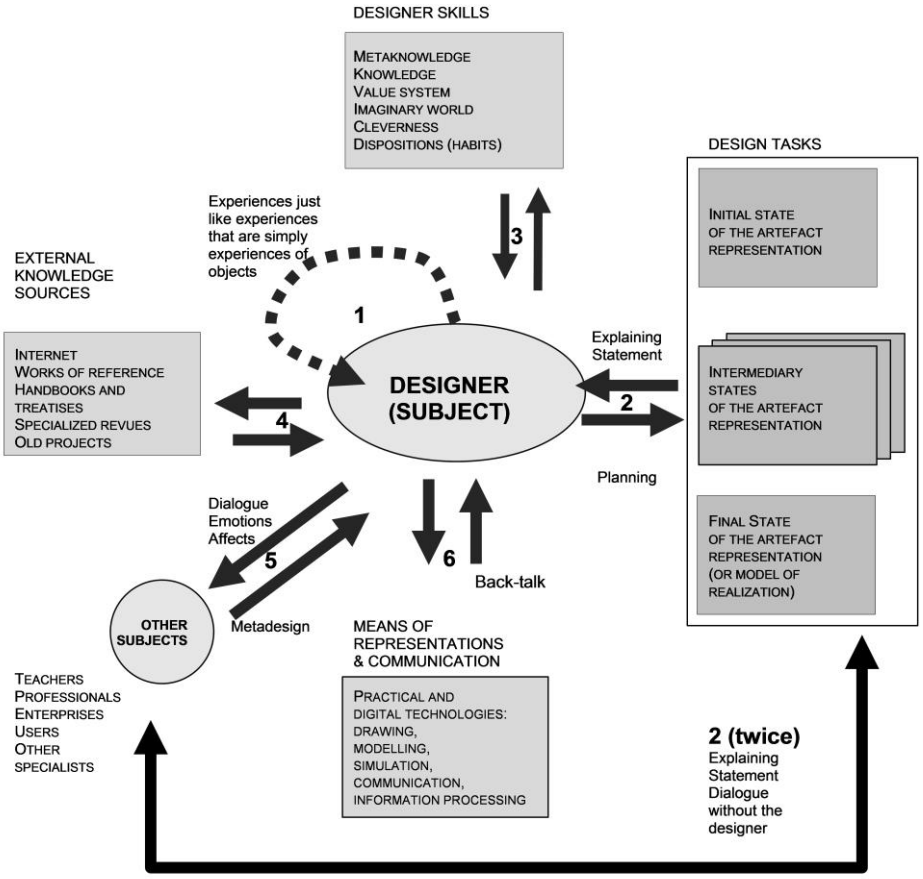



*Figure 1:* The complex situation of interactions (Lebahar, 2007; Tortochot, 2015)

In this way, the designer builds his/her design skills (3), such as by using his/her knowledge and meta-knowledge, value system, imaginary world, cleverness and dispositions. The designer fits his/her activities into external knowledge (4), with the Internet as a significant part. The designer also interacts with other subjects. He/she generates a "meta-designed" shape (5) thanks to a stated, shared and distributed activity (a needs assessment: Steen, 2013). The design activity becomes a meta-design activity; the design tasks are planned in a collective work and the design project becomes a process based on meta-knowledge, like so many representations of associated and discussed skills. At last, the designer's subject enters into a dialogue with a range of representations and tools or instruments – including the digital – that the subject uses to realise the design (6).

In a literature review, the anthropocentric approach is attached to the tool as a mediator of the activity. Mediation by the tools is involved in an activity, both for what it allows and by what it means, what it makes possible, and what it bounds (Leontiev, 1972). The tools have the potential to act that can be socially shared. This praxeology considers knowledge of the tool, or the mediating artefacts: tools and signs (Engeström, 2008) or the instrument (Rabardel & Béguin, 2005).

To analyse data from a given context, to simulate, evaluate and communicate artefacts, the designers establish planned and external representations (design task, i.e., the second and the sixth interactions with the subject [figure 1]): diagrams, drawings, geometric objects, mock ups, digital images, symbols systems, etc. Representations are essential instruments to carry out the design activity allowing the modelling of shapes, features and achievements from an abstract design. Ochanine (1996) named these representations "operative images". First, they set a cognitive function (the designer's subject can shape

the desired data he collected). The second is a regulating function (the designer's subject uses the "operative images" as an artefact to act with the data).

The diagramming tools used by designers for analysing data remain a substantial challenge in adapting and applying them in a given context (Cash, Stanković, & Štorga, 2014). Sketches made by designers during the design process play multiple roles for both designers and the design process (Purcell & Gero, 1998). They serve as an external memory to augment the limitation of human cognitive abilities, as the medium that designers use to communicate with themselves and others (first and fifth interactions in figure 1), and as the triggers that enable designers to reason about a design problem (Goldschmidt, 1991; Schön & Wiggins, 1992; Goldschmidt, 1997; Gero & McNeill, 1998; Kavakli, Suwa, Gero, & Purcell, 1999; Suwa, Gero, & Purcell, 2000; Bilda, Gero, & Purcell, 2006).

*Learning the design as a "devolution"*

Beyond the operational design activity, the learning situation allows to understand the constructivist process of design skill. In a training situation, the learner produces the conditions and the means of his/her future activity (Lebahar, 2009; Tortochot, 2012). As in the technological and artistic education, learning activity of DAA falls within the construction of meaning through the teaching-learning situation. According to the socio-constructivist frame of knowledge, the relationship between subject and knowledge is mediated in part by the objects the subject builds and also by the social interactions it has with other subjects (Vygotsky, 1978). The task's devolution (Brousseau, 1998; Chatoney, 2013) the student engages in both cognitive and material responsibility and knowledge can be another appropriated theoretical framework in which the student oversees his/her own learning (a personal goal-driven process), while the teacher focuses on the relationship situation. The main purpose of the student is to perform the task as well as possible. The main aim of the teacher is to bring all the students to a common desired state of competency at determinate moments.

## Investigation

The purpose of this analysis and investigation is to observe the relationship between design task (the instruments the teachers use to structure their teaching framework) and design activity (how and why the students use them).

The analysis and investigation are based on the data collected as part of an on-going research, in which the intention is to observe a pedagogical situation through different theoretical objects (Lebahar, 2009), such as:

- planned organisation of the DAA teachers;
- productions the students made in various forms (drawings, commented drawings, photographs, texts); and
- students' feedback on their own work.

The design-learning situation is a summative test, called 'Multidisciplinary Project in DAA', planned in the senior year for a duration of 75 hours. This test is organised in the classroom by the teaching team (a real project-based-learning). The students' written, graphic and oral productions are evaluated in three stages successively (Figure 2): the preparatory phase and research project (Phase 1) and its realisation (Phase 2) are assessed by their teachers and the project presentation (Phase 3) is evaluated by an external jury.

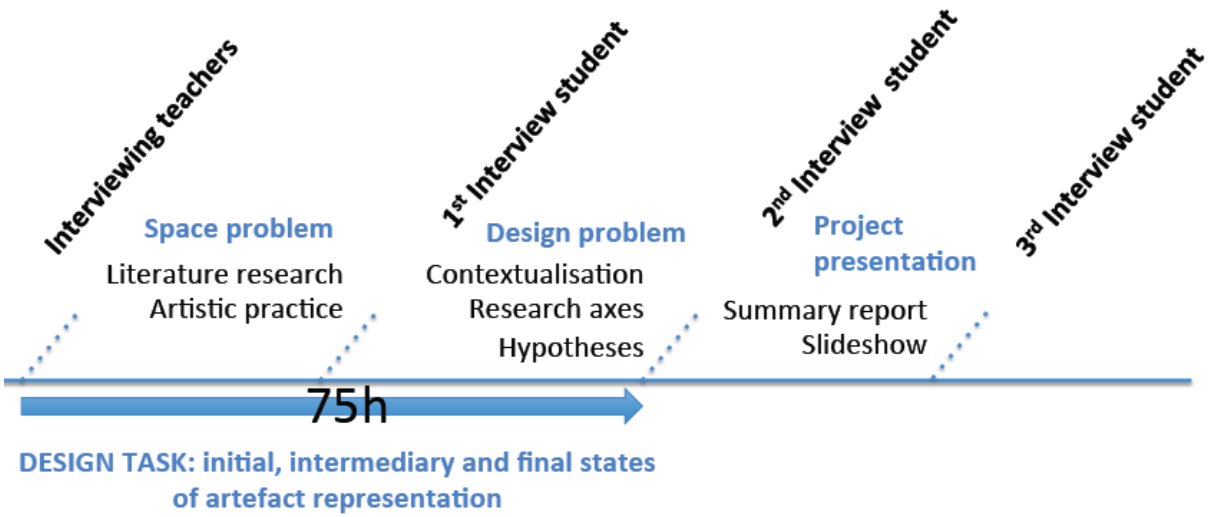



*Figure 2:* The design task in the learning situation: the multidisciplinary project and the different stages of the research

The project is always planned in five stages as follows:

1. At the beginning of the project, each teaching team proposes a topic.
2. According to the tasks required by the teachers, students must engage at the same time in both a literature research and an artistic practice.
3. Then, each student defines a space problem: his personal analysis of the topic allows him to point out a question. It is the end of phase 1 that validates his appropriation of the topic.
4. The space problem becomes a design problem: each student chooses a design field, makes clear a context and infers some requirements as specifications and constraints induced by his design problem.
5. Its design task consists of defining research axes and developing several hypotheses. It is the end of Phase 2. The assessment is based on the process that leads students to produce rather than the production itself.

After the project, according to the teachers' requirements, the student writes a summary report of the project. At the end of the year (Phase 3), he/she presents his/her project to an external jury. This last part evaluates how the student reports on his/her project approach.

## Methodology

The psycho-semiotic analysis leads to observe several objects that allow to describe and explain the production, the transformation and the use of representations (Lebahar, 2007): assigned tasks by the teacher; intermediary and final answers with different shapes (drawings, photographs, story-boards, texts, etc.); students' comments on these representations. The first aim is to identify the necessary cognitive and symbolic mechanisms of the project implementation. The second is to unveil the pedagogical situation: relationship between the subject who learns and the subject who teaches and with the context the teacher mobilizes to allow students to adapt specified knowledge.

In three French high schools, teachers and students were asked to participate before, during and after the Multidisciplinary Project, from January to June 2016: for each high school, a pair of teachers and three students were selected. Thus, with nine students (called by their initials), a total of 27 interviews were conducted before, during and after the analysed activity (Table 1). On one hand, data used in this study were collected in the same high school. It allowed to focus on one kind of task-activity connection (a comparison between high schools would be the next step of this ongoing research). On the other hand, excerpts from interviews were from the two first phases of PBL and from the three high schools. To analyse the dialogues between teachers and students, the choice was made to analyse the statements of all the students and to present only peculiar cases.

*Table 1:* The collected and analysed materials

| High school | Student | Interview | | | Production | | |
|---|---|---|---|---|---|---|---|
| | | Phase 1 | Phase 2 | Phase 3 | Phase 1 | Phase 2 | Phase 3 |
| | | | | | Quantity of boards | | Summary report |
| Diderot | CR | 18' | 20' | 21' | 10 | 14 | • |
| | CC | 20' | 18' | 22' | 6 | 11 | • |
| | WM | 24' | 26' | 21' | 7 | 12 | • |
| Mistral | TR | 37' | 28' | 24' | 9 | 7 | • |
| | NN | 26' | 24' | 21' | 8 | 8 | • |
| | AL | 25' | 22' | 19' | 9 | 8 | • |
| Hemingway | CK | 24' | 23' | 19' | 8 | 11 | • |
| | CH | 20' | 25' | 21' | 8 | 18 | • |
| | JR | 24' | 27' | 20' | 10 | 11 | • |

The students' design activity was explored using empirical methods—analysis of recorded documents (photography of students' production) and analysis of transcriptions from interviews (in the form of chats).

Then, the students were asked to reflect on what they were producing, what they said about the requirements, the dialogues with their teachers, and the assessment value. These questions were similar. Other questions considered the data from the participants' productions, such as: why did they choose those tools and not others? Were those tools useful? What did they learn with and about these tools?

In the first instance, data from the participants' productions—writings, photography, collages, weavings, sketches, design solutions and design synthesis—were used to observe and gain insight into the cognitive process and choice of tools in design activity. Following this, the transcriptions from the interviews of the participants were analysed. The entire interview transcriptions were not reproduced; only the sections said to be relevant to this investigation were included here. To synthesise and show only the essential ones, all the representations were not used.

As the designer's subject (figure 1), the student enters into a dialogue with a range of representations, tools or instruments at different states of artefact representation. To illustrate the first intermediary state of artefact representation, the next two tables point out various and singular space problems defined by

students themselves. Table 2 gives an example for each topic and table 3 is focused on the topic "Parade".

*Table 2:* Examples of space problems and design problems according to three topics

| Student | Topic | Space problem | Design problem |
|---|---|---|---|
| WM (Diderot high school) | Parade | How to denounce a situation through a temporary action? | Communication campaign during the Education Week against Racism and Anti-Semitism, France |
| TR (Mistral high school) | The experience of fragility | How to soothe the nervousness in stressful waiting situations? | Interactive animations in waiting areas |
| CK (Hemingway high school) | Around the time | How to explain in a playful way to a broad audience scientific data about the relativity to stimulate imagination? | An « object-book » for a science congress |

*Table 3:* Examples of space problems and design problems according to the topic "Parade" (Diderot high school)

| Students | Space problem | Design problem | |
|---|---|---|---|
| | Parade | Context | Design field |
| WM | How to denounce a situation through a temporary action? | Communication campaign during the Education Week against Racism and Anti-Semitism, France | Graphic design |
| CR | How can the extravagance disrupt our benchmarks? | Microarchitecture, resting place for hikers. Park entrance creeks of Luminy, Marseille | Environment design |
| CC | How can the deformation and the exaggeration reveal the strengths of an entity? | Marlou Van Rhijn holding, Dutch athlete (amputated both legs) featuring its prostheses. Paralympic Olympics opening ceremony, Rio, 2016 | Fashion design |

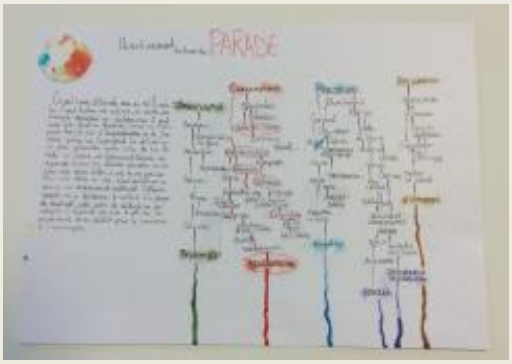
Table 2 shows the topics teachers required (based on the national curriculum) for each high school. It also shows the way students made those topics their own and how they transformed them into design problems. Table 3 shows how each student from Diderot high school transformed the "Parade" topic in a singular space problem and, within the design problem, in a context and in a design field (Dorst, 2006). Each student draws up a different space and design problem; there is no commonality, no copying and no similarity (Lebahar, 2009).

Based on these initial findings, activity analyses are set up to attempt a precise characterisation of the teaching-learning processes at stake.

*Table 4:* Production photographs of WM (Phase 1)


The students made several productions to present and communicate their ideas and their space and design problem (Table 4 and the WM productions).

*Table 5*: Board photographs and depiction comments (samples)

| Productions | Comments (depiction) |
|---|---|
|  | • WM uses words as an instrument of mediation in this initial stage of design activity.<br>• WM creates order on the support: a title area can be identified to the top; to the left, a handwritten text describing the theme; and to the right, a significant area of the support is used to display words that show their connection by their alignment. Some of these words are circled or highlighted with a different colour. |
|  | • WM has created a collage of diverse images and text.<br>• WM has outlined or coloured some elements of the collage in red.<br>• WM has used mainly figurative images in this collage.<br>• WM has used a majority of black and white images in this collage. |

All the boards were depicted and commented like the productions of WM (Table 5).

*Table 6:* Analysis of excerpts (samples)

| Interviewer | WM | Analysis |
|---|---|---|
| This choice to put a lot of photos was motivated by what? | I wanted it to be understandable in fact I wanted to put a lot of photos because they were plenty of direction so | • Being understood appears to be important to WM.<br>• WM appears to believe that accumulation and size can accomplishing 'understanding'. |
| And are these the words you put in bold? | It is these notions I want to bring out | • WM is aware of 'emphasis' |
| The heuristic map was a request from your teachers, do you find it a useful tool? | Oh yes, to choose direction | • WM acknowledges that a heuristic map is useful. |
| Ok and it really helped you in | Oh yes, a little because otherwise I would not have stayed, I would have gone elsewhere | • WM identifies why she thinks the heuristic map is useful. |
| Ok and the layout, arranging the photos in this way, was it also the request from your teachers? | No no it was I who chose | • WM *chose* how to structure her concept boards in phase 1. |
| Ok and sometimes there were images that did not show it enough or … | Yeah and the teachers also said that it does not show it enough | • WM acknowledges that some images were not correct. |
| Ok. Did the remarks they made help you? How did it happen? Did | Um not necessarily specifically, but just to check if I was not going little astray, otherwise it is ok | • WM appears to be concerned mainly with staying within the boundaries or following the rules. |

| | | |
|---|---|---|
| you have any specific questions to ask them? | | |
| You were able to associate them with sketches and texts. What was your purpose for the sketches? | To pick out the principles that emerged and to find the way in which the artists denounced something | • WM explains that her sketches were used to help decipher the work of other artists. |
| What do you think were the objectives of the first phase? | oh, to find concepts and principles to find a clear context | • WM is aware that the goals of phase one of the project were to discover notions and principles concerning the theme in order to propose a clear context. |

Built on the depicted and analysed boards, the interviews pointed out the explanations the students uttered to defend their choices, their tools, etc. (Table 6). While all the collected materials (Table 1) have been used to analyse the pedagogical situations, a few are even utilized in the outcomes part.

## Outcomes: a design learning process

### *Mind map: from a tool to an instrument*

As with other diagramming tools, mind maps can be used to generate, visualize, structure, and classify ideas, and as an aid to organising information and finding keywords to collect data on the web. In one high school, the teachers require students to make it before and during the search information task, which consists of supplying multidisciplinary resources about the topic, called "large sourcing", to find their search direction.

The focus on a student's mind map (CR, WB) (Tables 4 & 5) outlines the instrumented activity during her design-learning process.

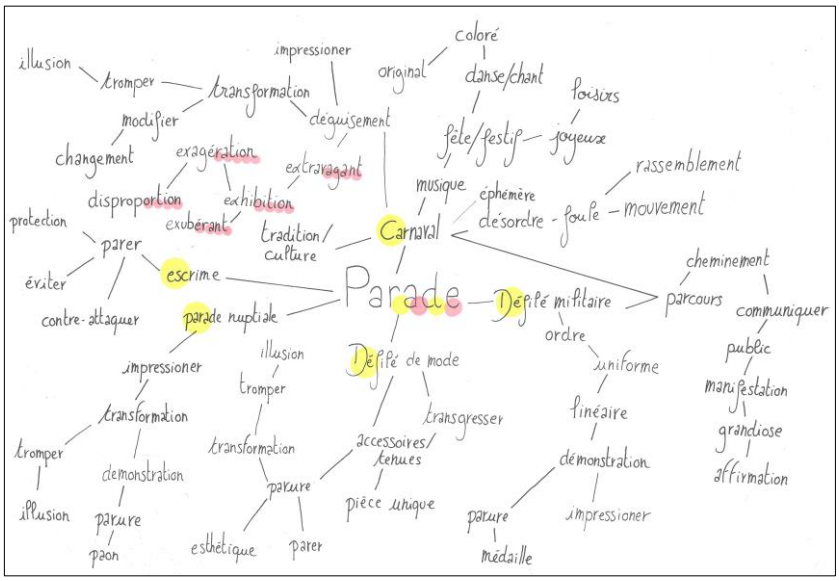
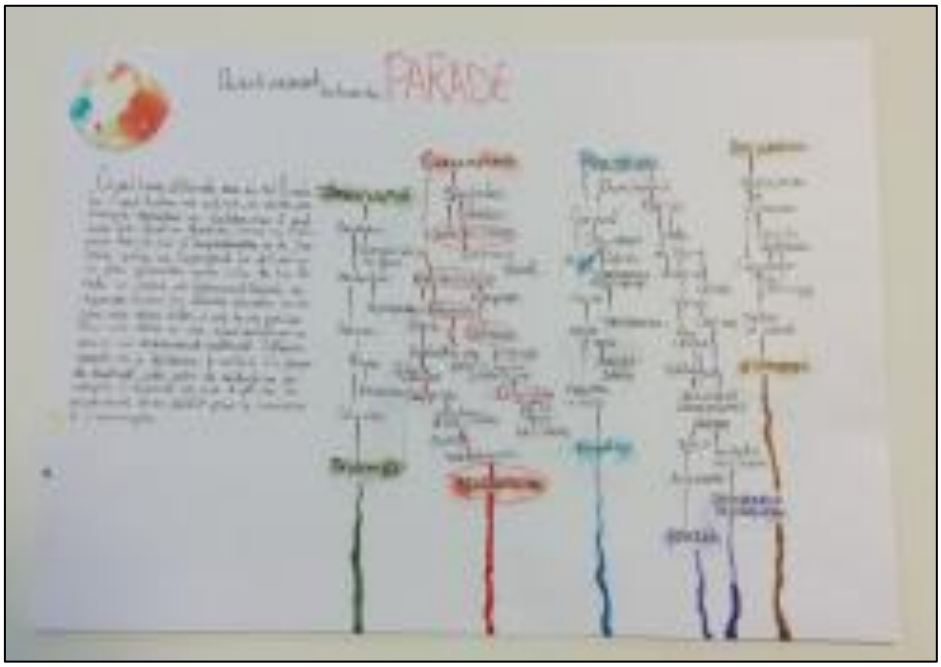



*Figure 3:* CR student's mind map and her answer to the question: is this tool helpful to you?

> it served me so much because for my 'large sourcing' I tapped into the mind map all words, the yellow words are squarely my 'large sourcing'. And even the pink words I wrote after that guide my direction so it is very useful to me.

*Figure 4:* WB student's mind map and her answer to the question: is this tool helpful to you?




Yes, to find my direction because otherwise I would not have stayed, I would have gone elsewhere

The epistemic and pragmatic functions of this diagramming tool can be used for production of inferences, construction of representations and creation of procedures (see comments on Table 5 of production of WM). We can suggest that the mind map is an instrument for both the student and the teacher, developing student's ability to think about design in meaningful ways and evaluating the student's process in his own ways-stations that lead him to discover and create a warranted interpretation.

The focus on a student's (CC) project, in the "intermediary states of the artefact representation" (Figure 4) outlines the instrumented activity during her design-learning process. The CC student's space problem is: "How can the deformation and the exaggeration reveal the assets of an entity?" Her design problem is to design Marlou Van Rhijn's ceremony clothes, for the opening of the last Paralympic games.

*A problem anchored in reality*

In the first interview (Table 7a), the student CC was asked what context means. Her answer outlines how she perceives the task and its constraints. For her, the context is "to find an event or a place where one would like to do a work (…). It must meet the demand of a company and there must be constraints, demands and stakes in relation to the customer: to whom, for what, when, and how. And finally, how one can answer this question at the request of the company or the customer".

*Table 7a*: Analysis of excerpts from interview with CC (phase 1)

| Interviewer | CC | Analysis |
|---|---|---|
| Okay, so is that the next step? | Yes, the next step is the context | |
| Yes, and what is the context, what is being asked? | The context is to find an event, a place where you would like to do a project, should have this (...) should meet the demand of a company and there should be constraints, specifications and stakes according to the customer: for whom, for what, where, when and how. How can one answer this problem, in fact, at the request of the company or the customer? | • CC details how she perceives the task and its constraints.<br>• CC identifies the various elements requested to define a context. |

In the second interview (table 7b), at the final state of artefact representation, her feedback on her own work highlights a design activity and a development of design skill in a design situation. The topic "Parade" requested by the teachers led CC to formulate a problem and then define her design task: to propose "outfits" for an amputee in both legs Dutch sprinter for the opening ceremony of Paralympic games.

*Table 7b*: Analysis of excerpts from interview with CC (phase 2)

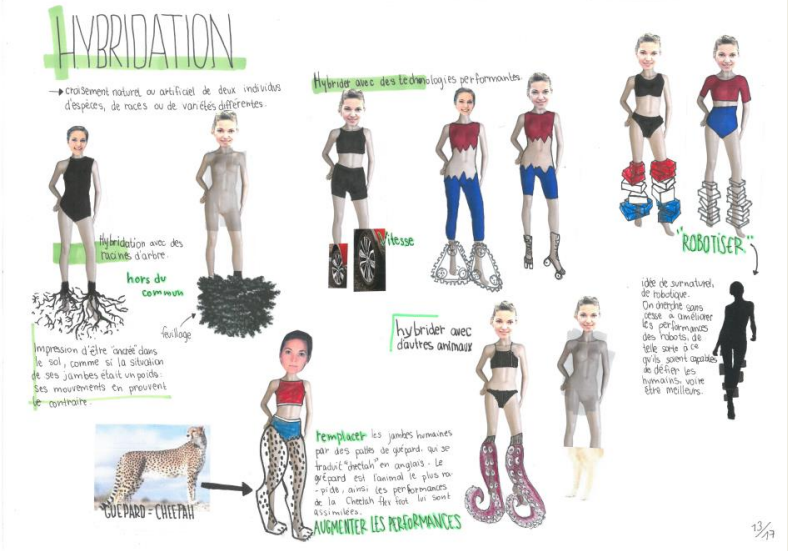
| Interviewer | CC | Analysis |
|---|---|---|
| Can you tell me the starting point of your project, where did you start for this second phase? | So from my problematic "How can deformation and exaggeration reveal the strengths of an entity?", I looked for a context which could put in dialogue the deformation and an asset so I did several searches and I found the Paralympic games in Rio taking place in September 2016; so, uh after I checked out and uh there was an athlete, a sprint runner who was an amputee in both legs and who was equipped with prostheses that are called the "Cheetah flexfoot"; and so uh by that I decided to create an outfit that highlights her handicap and uh that can reveal his prostheses. | • CC describes the design activity: how she has proceeded step by step to define her design problem at the beginning of phase two.<br>• CC specifies why she chose this context in relation to the task constraint.<br>• CC appears to be concerned mainly with following the rules. |
| Then you started to talk about it with the previous question we'll go a little further. Can you describe to me the work that you did from there? | Well, I had to create an outfit that will be worn by the athlete Marlou Van Rhijn during the opening ceremony of the Paralympic Games and this outfit is designed to highlight her prostheses without cluttering her movements and in outfits I had to use the distortion distortion and di ... uh I do not know anymore. | • CC defines her design problem: a context, a design field, a constraint.<br>• CC appears to be having some difficulties in communicating. |
| During this phase, what has guided your work? Was there a common thread from the time when you had your context? Have you had a goal? | Well, my goal was to stand out from other projects because it's not trivial to work on disability and the Paralympic games because in my research, I saw that it was not publicised and I really wanted to talk about that. | • CC specifies why she chose this context in relation to her personal goal.<br>• CC appears to be concerned mainly with disability. |

CC explains how she perceives the task and its constraints. She must develop a concrete experience, opposing two notions cleared in her space problem, to "put in dialogue deformation and an asset". She defines her design problem: a design field "to showcase her physical features" and a constraint "without cluttering her movements", "to stand out from other projects". The choice of this context is motivated by the task itself (the space problem must become a design problem) and her personal goal "to work on disability".

*From sketches to ideas*

The following data (table 8) show how sketches play multiple roles during her design-learning process. The student makes sketches of intention; she does not know where she is going, but produces with great freedom whether it is through the tools or the supports she uses and she finds ideas.

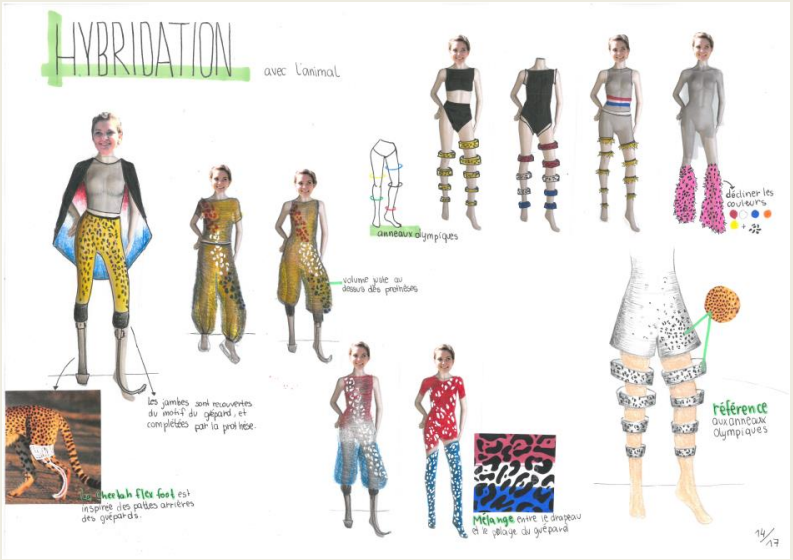
*Table 8*: Comparative analysis of excerpts from interview with CC and her production

| **Excerpts from CC interview** | **Analysis** |
|---|---|
| Sometimes I did not know at all about what I was going to do, but I was researching, I made sketches of intention and it gave me ideas for proposals." | • CC describes her design activity.<br>• CC states that she had no idea at first and sketches of intention helped her to develop her project. |
| "I used the pen a lot but it refers not what I wanted to (...) but it is a tool with which I am comfortable but now I'm more comfortable with others as I learned to use other tools with this project." | • CC identifies the tool she is most comfortable with.<br>• CC states that during the project, she has learned to draw with other tools. |
| At the beginning, I had models and there were no head and a teacher told me that it would be more communicating to put the athlete's head directly, so that one puts oneself in situation that one sees directly the athlete. But otherwise I would never have had this idea myself. | • CC relies on the suggestion of a teacher to make her sketches "more communicative". |
| **CC's production** | **Analysis** |
|  | • Drawing felt on photographs of a model, foliage photomontage, car wheels, giraffe legs.<br>• The photo of the athlete's head is pasted to each mannequin.<br>• The statements represent initial states of representation:<br>- "Impression of being anchored to the ground as if the situation of her legs was a weight"<br>- "To replace the human legs with cheetah paws"<br>"Idea of supernatural, of robotics"<br>• The statements specify the graphic intentions:<br>"Out of the ordinary", "to replace", "to increase performance", "to robotize".<br>• Arrows link text, photography and sketches. |

The student talks about her meaningless drawing action, which generates ideas and she uses an "easy" tool for her. But the student gets a clear understanding of the limits of this tool—when she looks at her productions—and of the necessity to choose other tools to communicate her ideas. Her productions show that she has used other tools to generate ideas; she cuts and pastes photographs, and she draws upon them. She used a basic model to help herself to evaluate, open out and develop her intentions and to communicate her design process. These data evoke Schön's reflective practitioner.

During her design process, the association of an analogy, the prosthesis, called "Cheetah" and the Olympic rings produced a triggering element. The following data (Table 9) outline on one hand how the intermediary states of the artefact representation have been influenced by a case trigger and on the other hand, her awareness of producing the conditions and the means of her future activity.

*Table 9*: Comparative analysis of excerpts from interview with CC and her production

| **Excerpts from CC interview** | **Analysis** |
|---|---|
| "I found the hybridization with the animal interesting because first, there's a relationship with the cheetah and I could open out the idea for example here with the Olympic rings. I played with the rings and opened out this idea with several patterns, many colors, many forms and that's what I found interesting is to start from the Olympic rings that are quite ordinary to get a more thorough and completely different result." | • CC identifies how her idea of "hybridation" has given her concrete operational decisions.<br>• CC explains where she comes from and where she arrives: an awareness of what a design project is. |
| **CC's productions** | **Analysis** |
|  | • Groups of drawings felt and color crayons on photographs of a model.<br>• The photo of the athlete's head is pasted to each mannequin, except one.<br>• A sketch of two legs with colored rings.<br>• A sketch of two legs with mottled rings.<br>• A pattern sample<br>• The statements indicate graphic intentions:<br>- "Cheetah Flexfoot".<br>- "Reference to the Olympic Rings".<br>- "Mix between the flag and the coat of the cheetah".<br>• Arrows link text, photography and sketches. |

The utterances and the productions show how the student acts with her representations (mental images, operative pictures) to "open out" her idea. She enters into a dialogue with a range of representations and tools to create decisions about her design activity. She organises her board in different orientations to play "with several patterns, many colors, many forms", making groups of sketches, photographs, samples and handwritten text.

*The dialogue with the teachers: an instrument to guide, to stop action*

In the three high schools, the teachers periodically listened to all the students about their productions, providing feedback at the different tasks. Representations can be meaningful in drawings (Ochanine, 2008), in verbal utterances and in their organisation of the action (i.e., the dialogic dimension of Engeström's activity theory). Thus, it gives concrete operational decisions for both students and teachers.

> Every beginning of the session we told them about our project, they told us each time that we could develop, what we have forgotten, they helped us well, they even gave us solutions if we were truly lost.
>
> Every week we had to see her again. This is a mandatory interview with Madame. But it allowed me each time to refocus on the problem. She doesn't stop me, but for the hypotheses a little ... she told me it doesn't work, for other she told me it works.

First, we see that the teachers follow students' activities to guide them effectively (Lebahar 2009, Tortochot, 2012).

The teachers' speeches are based on the previous experiences of the multidisciplinary project. Those are not transcribed in this paper. However, it appears that the oral discourses the students have to make are very significant as part of the assessment. In a way, one of the pedagogical points of AA teaching could be the "emergent function of assessment" (Gaillot, 1997), using the verbalisation of the stakes and knowledge involved.

In the first two transcriptions, the guidance seems to be motivated more by design problems than learning problems. This raises questions about the effectiveness of the guidance for the student's activity, its nature and its limits (Ginestié, 2008).

> It was they who come to see us, they made sure to see everyone. They helped me to improve my propositions, to do more in fact.
>
> They asked me to play on a principle, for example, to reduce it.
>
> It has helped me to decline my propositions.

In the last transcription, teacher guided the student in finding a procedural method for developing the student's ability. By using this help, the teacher allowed the student to overcome the difficulties with which he was faced to accomplish the task.

## Discussion: practice and impact of instruments in STD2A curriculum

According to the findings, AA teaching is neither artistic education (Gaillot, 1997) nor technology education (Ginestié, 2009). It is a design practice, composed of several problems, multifaceted and having different scopes. The DAA syllabus and teachers require students to use tools to "create", "discuss", "investigate", "control", "survey", and "train" (MEN, 2011); this is a "cognitive orientation" of the curriculum (Jackson, 1992). Students do not only follow the specifications, they also organize their tasks, utter what they intend to do, and share the tools with other subjects (Lebahar, 2007). In this way, tools are seen as mediating artefacts or instruments (Leontiev, 1972; Engeström, 2008). The mediated activity is one of the main features of the designer as a subject (Lebahar, 2007): interactions between valuable instruments like external sources of knowledge, means of representations, other subjects and the skills it developed and design tasks it led (figure 1).

The view of design learning situation in vocational education (Moineau, 2011; Tortochot, 2013; Farsy, 2013) pointed out that this situation is a construction of representation tasks. As mentioned in the

introduction, the DAA syllabus does not train professional designers, but the first outcomes show that students' activity is a designer's activity because they design and share their design with tools, build task representations as operative images (Ochanine, 1996) and develop design ability (Lebahar, 2007). What the students say about their work outlines a design activity where requirements of design task are complied with and where instruments (like mind maps: Figures 3 and 4) are decisive for the guidance and development of design ability: instruments help students to reason about a design problem (Bilda, Gero & Purcell, 2006), to acquire a great consciousness of their design (Schön & Wiggins, 1992).

For DAA teachers, the "Multidisciplinary Project in DAA" gets a Certification status and the prescription insists more on the process that leads students to produce than the production itself. It strongly encourages the teachers to control the activity. The teachers create the conditions that allow the analysis of the problem, the description of the task and build a guidance base (Ginestié, 2008). They could lead students to create new problems thanks to their representations, and design pedagogical contents could be built on a cognitive ergonomic approach of design: they draw up different spaces and design problems (Dorst, 2006) in which there is no commonality, no copying and no similarity (Lebahar, 2009). But setting up such project activity in a design-learning situation in a secondary school is a difficult task. First, it is necessary for the teachers to be able to closely follow students' activities, to guide them effectively and such guidance must be progressively reduced to leave the students to be able to really learn. Moreover, the teachers must be able to differentiate between what springs from purely learning problems and what comes from design problems.

## Conclusion

Two dimensions of the multidisciplinary project are pointed out in the DAA syllabus: a teaching-learning situation and a summative test. The main goal of the students is to perform as well as possible the task, but each student gets a personal goal-driven process. This situation sheds on light a practical implementation of the devolution (Andréucci and Chatoney, 2006; Brousseau, 1998; Chatoney, 2013). The task's devolution by the students engages them in both cognitive and material responsibility and knowledge can be appropriated. The first results show that students' activity, a real design activity, is actually and strongly guided by teachers. Further analysis of the students' verbal data could differentiate the clues of piloting activity or guiding actions.

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