TRAIN THE TRAINERS ON LEARN GEOMETRY BY DOING

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Abstract

In this paper we describe how, starting from our experience of Geometry’s teaching in two different academic contexts (mathematic and drawing), we identified together common didactics tools in order to educate the reading of the geometric shapes and their properties with particular attention to the architectural cases. To do this we use 3D models (for example origami models) and gaming activities, both with students and with trainers and our lessons are held not only in the classroom but in public places such squares or cultural sites.

Today, we use our teaching idea to train the trainers to understand how to teach geometry in each kind of school level in a new way, using a tangible geometry.

Keywords: teaching, geometry, learn by doing, edutainment.

1 INTRODUCTION

We believe that training is a role playing game in which the trainer has to interact with other participants knowing grasp the potential and limitations.

The actors involved in a training program are many -teachers, students, trainee’s students- as well as many are the dynamics that develop between actors and places of learning. To observe the relationships between the different actors we think that is necessary to work together and we believe that the best solution is a practical activity. Moreover, since one of the main problems of education is to make people interested, our strategy is to have fun: theory and practice, lectures and workshops, concepts and projects, which is why we chose edutainment and origami.

Origami, an ancient art of folding (and in certain contexts, cutting) the paper, has in fact proved to us a tool consistent with what emerges from the cone of knowledge proposed by E. Dale [1]; this cone shows a graphic depiction of the relationship between how information is presented in instruction and the outcomes for learners. In more recent years, J. Dewey [2], putting students at the center of the cognitive process, underline a continuous relationship between thinking and doing.

For years we have used this practical approach to teaching geometry in our didactic contexts (see in this book, papers “Activities in mathematics course for undergraduate students: from origami to software”, by M.L. Spreafico and “Observe, understand and represent an architectural shape: methodological and practical approaches” by U. Zich). In the last few years we have worked together with interdisciplinary teaching and research projects ranging from university level to childhood [3], making tangible geometry to visualize theoretical concepts. These direct teaching experiences have led us to test an experiential learning mode, in the idea of Piaget, who recognizes at the time of manipulation [4] the first moment of knowledge accessible to many. Being transversely and easily shared, it gives us the possibility of transmitting the methodology to other teachers with workshops and targeted seminars (see subsections 3.2.1 and 3.2.2).

Learning processes are always articulated and differentiated; in our laboratories the interactions between teacher and student are mediated by physical manipulation, certainly not standardized; it follows that we cannot enunciate a didactic theory but only describe a personal experience that led us to teach classroom students to share working tables with other teachers and, ultimately, to design their training on multiple levels, aimed at reproducing similar experiences, even if they are reconsidered in their contexts.

Moving from teaching to students to that to teachers, it was necessary to do first that role-playing role that required the change of point of view to understand how to move from both sides of the chair. That’s the way we do training requires the involvement of teachers in the field to directly test the practical activities for students. The teacher has to be able to change its point of view -to better understand the audience- working from the both side of the chair.
The experience will allow them to present it again in class with dynamics similar, although not identical, and learn more about their partners.

2 METHODOLOGY: ACTIVE TRAINING

The fundamental philosophy of our activities is that of Learn by doing; we are convinced that the theory becomes not only easier to understand but also better understood and longer memorized if the student can put it into practice. This is more effective if the practice is offered through engaging activities and in a gaming look, which put students at ease, even those frightened by the mathematical name of topics. We range therefore from gaming activities to paper modeling of geometries that we want to explain and that we always try to find in the space around us. This way students discover that they are able to do with their hands 3D model of objects that they usually believe they have only seen on books, having not received training in observation.

Our educational approach provides an approach not only practical but also applied for students as for trainers, so that lesson’s site becomes lesson itself, so every teaching contribution starts with the geometric description of the environment to get a description and a first synthetic modeling.

Moreover, the cone of experience summarizes the effectiveness of the cognitive approach in training: if few people remember what they read, there are many more that remember it if they see an image and even more those who learn it through a direct experience. So moving from passive to active training means going from seeing and listening to touching and verbally and/or graphically describing or even modeling. And so the reading of hidden geometries in the host site allows multi-level involvement of listeners: the remarkable versatility of modus operandi, characterized by language flexibility and contextualization of experiences and interpersonal skills, is such that in the students the curiosity comes of what else can be modeled and in the educators the astonishment comes of how easy it appears to visualize a theoretical concept, which sometimes is complex to verbally describe.

Subsequently, the training leads to overcome the appearance above and to enter the merit of the underlying theory. Just so the experience becomes education and the reading method of the environment becomes reproducible in any site and will push the trainers who are present to design their own activities by choosing sites rich in geometry for a new reading of the environment.

3 WHICH TRAINERS?

The role play metaphor suggest us that it is necessary to understand the rules of the game and the actors involved: there are many types of trainer, each with its own specific needs, as well as different teaching methods and possible declinations of practical experience.

Below are some of the exemplary experiences ranging from didactic projects with medium-long implementation times, conferences and study days, to end up with the training of trainers on specialized educational activities.

3.1 Teaching Project

In this section we present two different teaching projects with two different dynamics: on the one hand the project developed by working directly in classes with children and teachers; on the other hand, training was done directly with the teachers.

3.1.1 In the classrooms

Within the five year period (2009-2013), a teaching project with Emma Frigerio - of the University of Milan - at the “C.Gallazzi” primary school in Busto Arsizio (Va, Italy) a teaching project was developed, following the training of two parallel classes, from the entrance to the primary school to the exit. The project [5] aimed to propose some mathematical curriculum topics, linked to both geometry and arithmetic, using origami with the philosophy of learning-by-doing.

Every year 4 or 5 lessons were held in the classroom in the presence of teachers. This has allowed us to test the workshops, observe children difficulties and the strengths of the used method, allowing us to design a structured path.

Teachers had a double task: as subjects to be trained, they participated in the activities by observing content and modalities, to learn the methodology; as trainers of their students, there was a constant exchange of views with us and observations.
This long training has meant that many of them not only reproduce our lessons, but are autonomous in the production of others. In this first case, the subjects to be formed were observers and participated in the lesson.

This experience has allowed gathering much material related in particular to geometry. This material was then used as a starting point and was partly reinterpreted in the activities the authors have subsequently conceived on shape reading.

### 3.1.2 For the classrooms

A second training project for some fifty primary school teachers, involved the first author in the 2016-2017 school year. This project has been sponsored by our University Department (Politecnico di Torino, DISMA) and closing agreements with the Primary School of Marconi Circus, Collegno (Turin, Italy). In this case, relying on experiences with the children in the previous project and on interdisciplinary insights into drawing that took place in these years (see subsections 3.3), a series of 8 lessons were held only to teachers, developing with them the project designed for the "C.Gallazzi" school.

At first the teachers followed the training course, then tested lessons in the classes and discussed the results with the trainer. During the first training moment, the teachers, divided into two groups to reproduce the situation of a class, played the role of students and the trainer that of teacher; while, in the second moment, they recovered their role of teachers and, finally, they related to the trainer in an "au pair" exchange.

### 3.2 Workshop for trainers

In this subsection we expose two different type of activities directly addressed to teachers.

#### 3.2.1 One-day workshops

We had the opportunity to organize training days starting from a precise request for a school plexus. Some deans, knowing our teaching methodology, have invited us to train school teachers by providing us with a precise target of use.

In all cases, precisely for the specificity of our method, the structure of the training day is similar. The morning is dedicated to theoretical conferences that show how the general method of learn-by doing and origami as an instrument can be applied to various disciplinary aspects.

For training to be complete, at this stage we also involve other professionals who use this philosophy even in areas far from geometry, such as narration or recovery of disadvantaged children (dyslexia and dysgraphia). The afternoon is devoted to experimentation by trainers who become students in our workshops. In general, we organize parallel workshops where we divide into small groups the teachers who thus experience the classroom situation.

Obviously the content is calibrated with respect to the users.

For example, in the day "Geometry and Oririgami. A perfect harmony of forms", organized for Lyceum Norberto Rosa of Bussoleno (Turin), the training was addressed to teachers of upper and lower grades.
lower secondary schools. Our disciplines, mathematics and drawing, were then present in specific and specialized workshops, adapted to the age of future student students.

The day "Education with Origami: Training and Teaching With Origami" organized with the school "C Gallazzi" in Busto Arsizio (Varese), was open to every order of school, with a particular attention to second-degree primary and secondary school. Here, besides our disciplines, we have also given space to other educational fields.

To make people understand the transversality of our disciplinary proposals it was explained how the same subject can be declined with specific language and applications for each age.

For example, the support for a treasure hunt designed in a Valentino castle hall for children of a fourth grade was shown to illustrate the flexibility and the possibility of contextualization in other sites.

![Figure 2. Treasure hunt in the Valentino Castle: how to recognize a shape and fold it. The map is drawn by trainee students and the image is by M. Pavignano.](image)

### 3.2.2 Conferences

In recent years, there have been many proposals in Europe for conferences taking place over 3/4 days entirely devoted to origami teaching and that are open to teachers and educators.

We recall, among others, the three Origami conferences, educational and teaching dynamics held in Bellaria (Italy) [6], the conferences of Freiburg (Germany) and those of Badalona (Spain) [7].

The authors participated in these conferences by providing theoretical lessons and workshops. Our institution recognizes the importance of these conferences, so that in the case of the Italian ones, they have been Sponsored by our University Departments (Politecnico di Torino, DAD and DISMA); and this is also the case for other university contexts.

![Figure 3. Workshop in Bellaria at “Origami, dinamiche educative e didattica” conference 2013.](image)
These conferences, always organized with theoretical lectures accompanied by practical workshops, are generally structured with sections devoted to various disciplines, which are also adapted to the age of the pupils they are addressed.

These conferences were not only training sessions for participants, but they were sometimes occasion for our trainee students to put into practice the skills they have acquired as trainers.

For example, in the Bellaria Conventions, trainee students held workshops related to activities developed with Venaria Reale (Turin) (see subsection 3.3.1).

Sensibility to this ancient art for a modern teaching is also recognized in more transversal educational contexts; for example, the authors have been invited to the Festival of Turin Education [8].

### 3.3 Course or seminar within an educational / dissemination project

The dynamics of training within an educational/dissemination project is certainly very particular because, if this project is long-term, it is articulated on multiple levels.

In that context, the training of the trainers doubles: on the one side, the formation of the people who will in fact, over time, follow the educational project, becoming trainers of experience; on the other side, the need to articulate the activities because the students' accompanying professors are not just users of an experience but access a reusable and rewritable method to continue the activities within their didactic pathway, thus creating an active synergy between the dynamics educational.

By way of example, the initiative is analyzed “The King and the Origami” –by the agreement between Politecnico di Torino DAD & DISMA and Centro Studi Venaria, we design an educational project for the understanding of architectural shape through the origami geometry in the royal residence of Venaria, was an opportunity not only to convey to students and visitors the geometry hidden in the architecture [9] -, by way is a multi-sensory experiential learning activity that involves the active participation of all the elements, is therefore crucial to the role of tutors, guides, accompanying teachers and, of course, students.

#### 3.3.1 Guides, tutors and trainee students

Drawing up the teaching project required logistic planning for the study of training paths and moments of rest so as not to interfere with normal guided tours within the structure and, to do so, it was crucial to relate to the guides that normally accompany visiting groups. In this phase of the project, a first relationship of mutual training was constructed, which was fundamental in the next phase of project design and, in activating training paths open to schools, it was therefore natural to involve the same guides and integrate them with a specific training. How?

By verifying step by step the six planned training paths, defining the intersection between places, contents and expressive modes, thus creating a workgroup where specialized tutors can count on the complicity of the guides and, if necessary, rely on architecture trainee students.

Their training was mediated between work desks and practical applications combined with the paths of visit we have personally managed. They have thus been able to be first observers, then collaborators and only in the last actor, forming in turn those who will assist this phenomenon of knowledge transmission by doing.

Here, then, an activity such as treasure hunt, in its declination for Secondary Schools that involves the recognition of complex surfaces in vaulted structures, becomes an opportunity to dialogue on content at all levels:

- the guide knows where to stop during the visit and he places the environment temporally and spatially, contextualizing it;
- the tutor introduces the geometric contents of it by referring to the combined workshop experience of origami design and modeling;
- the architect trainee student identifies its specifics and leads the hunt for recognition of shapes between play and training.
3.3.2 The users: Teachers and students

Direct observation and workshop conjugation allow some models of turned structures to be analyzed, declining them for the specific user, so that basics and applications of mathematics and descriptive geometry are transmitted through the origami technique in accordance with the curricula involved.

The first users are surely students in their experience immersive who are stimulated by direct observation also through didactics tools to understand the abstraction process and the recognition of simple forms.

At the same time, teachers acquire a new way of observing shapes so that they can continue to visit the outside of the residence looking for geometries in the gardens and immediately become privileged interlocutors for their students.

The materials to be shared with the attending teachers are constantly updated, because they are partly generated by feedback and therefore, given a large amount of pre-defined contributions and the availability to its integration, material transmission is almost "on demand" in order to respect every didactic specificities without "imposing the same [experience] on each visitor, establishing in advance what emotions each one may or will have to test the audience. In that case, the risk would be to provide pre-packaged experiences, more in line with another type of attraction than a cultural institution which is or should be the museum [10]

Graphical media used for direct experience are given to Teachers -so that they can retrace it later and, in case, lead in the design of their experiential path to another location with a focused aim for the context-. Complementary materials are given to integrate similar affinities unfortunately incomplete in the short visit time.
4 CONCLUSIONS

From our direct practice, we have understood how the experiential approach leads to an easily shared education with the repetition of similar experiences; the reading method of the surrounding world becomes reproducible in any environment and will therefore encourage trainers to design their own activities by choosing geometric place for a new experience.

The relationship between educators at all levels - sometimes with “peer” exchanges, sometimes impersonating roles and becoming, on occasion, “students for a day”- , working in different ways to build a new awareness of being able to reproduce experiential didactics as a teacher, in other places and in other contexts, foreseeing in turn the active participation of all the elements involved.

Careful attention must be paid to reading feedback in itinere.

Considering not only educational purposes but also dissemination purposes, it is necessary for all trainers to be able to grasp any difficulties in the users in order to redefine the operating modes and converge, perhaps, towards a new goal more rewarding and fulfilling.

The sensitivity of those who deliver a training course must be such that it is possible to change the didactic dynamics by declining the default format to go to new needs, if necessary.

The flexibility of the chosen tools, and specifically modeling with paper, can be achieved where other teaching methodologies have proved to be ineffective: the tangibility of the model allows the operator to overcome many barriers, including preconceptions.

As far as our experience with Politecnico di Torino is concerned, origami has been used for educational purposes, in some courses of representation and geometry, and have led us to create research fields ranging from architecture, mathematics and design, between training and research also in the direction “teaching for All”.

Figure 5. The King and the Origami: classification of vault and geometrical reading of shape.

Tables by trainees students.

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