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Experience of Material Tinkering from Waste in the Year 3-Year 5 Primary School Age Range as an Introduction to Design and Sustainability

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Abstract
A possibility increasingly experimented in the field of design to improve end-of-life sustainability is integration of agro-waste into materials. Design can "upcycle" waste, offering perceptive and aesthetical acceptance to objects produced from it. On-field experimentations can foster awareness over the possibility to modify objects lifecycle, avoiding a "use-and-throw" perspective, and exploring the identity of materials in their prospected field of application. This will be aimed at creating a bond between user and objects, based both on function and on affection, also considering the modifications the material can undergo over time, making it adapted to different uses. This practice can have a significant educational value: in particular, this study moves from an experimentation carried out at July and September 2017 by design and materials engineering researchers, with several groups of 15 children, age 8-11, at Museo dei Bambini-Explora in Rome, investigating their "experience" and "creativity" on the topic. Conclusions are also drawn on possible modifications of the step-like procedure to introduce students of all ages to the knowledge of experimental method through the production of DIY bioplastics from waste. This "trial and error" procedure allows reflecting from a play-like point of view on aspects essential for the success of this operation, such as mode of coloration, effect of texture, possibility of obtaining curved or complex shapes, mechanical workability, optimal cooking and aromatization. The consequence of the exercise is customizing materials obtained from waste, with the idea of teaching how an expressive and functional success of the objects produced can make these "resilient" over time, therefore inherently sustainable. This would lead, through a combined and simple teaching of elements of experimental procedure and sustainability, to an awareness of their respective importance in design. The tool for this result is the development of DIY materials. The significance of this experience, which could be applied also in other age ranges, appeared to be to communicate the role of design to improve the perception of materials by transforming them into valuable objects. This proved to be better explained in the challenging case of waste, hence a substance bearing no longer any emotional or functional relation with us, with which this "bond" needs to be rebuilt through an experiential path.
Keywords: design education; material tinkering; sustainability for children

1. Introduction

Differentiated waste collection may represent a privileged approach to introduce the characteristics of various types of materials in a wide range of different educational contexts, from preschool children to graduate students (Corsi 2002). This occurs because it enables not only to discern among materials categories, yet also suggests the possibilities that the materials have to produce objects or artefacts whose manufacture would respond effectively to the strategies indicated with the "three R" (reduce-reuse-recycle). These are considered a paradigm leading to the reduction of environmental impact, as expressed by carbon footprint, and are therefore widely applied in education on technology and design (Chawla and Rajaram 2016). This approach, extended to design education, would in the first instance result in a sounder reflection over the end-of-life of the object.

In more general terms, recycling as a general strategy has been recently challenged, since this procedure leads, namely in the case of plastics, towards obtaining materials with lower physical and mechanical qualities, therefore to be employed in applications with lower requirements in terms of performance (Hopewell et al., 2009). Quite obviously, the perplexities about recycling would bring to the forefront the other two Rs: in understanding how to effectively reuse and reduce waste, design education would be also very important, since design can give value to the objects obtained by these practices. In particular, it can be noticed that reducing the amount of waste would imply redesigning an object by applying strategies, such as using less material to serve effectively the same function, while on the other side re-use means offering a second life to the whole object or parts of it, a possibility that is more easily achieved in case the object is designed for this purpose (Charter 1998).

Concentrating on the conception of a "second life" for the object, this would more generally bring to

indications over the re-use of materials transforming (or remoulding) them into new or renovated objects, with the idea that the new form obtained would possibly result in rebuilding the "bond" existing between the object and the user, which was worn out overtime and led to discarding the object and considering it as waste (Bramston and Maycroft 2014). A simplifying and educational observation in this regard is that the "three R" would be completed by "other Rs", in the first instance by a renewed reflection over the importance of repair, for example. This is particularly significant in that the reparation of an object leads almost inevitably to the need to rethink it, for instance redesigning junctions or using different materials. Initial qualitative considerations would lead to investigating on the effectiveness of the way the parts or materials are joined together: this would overtime leave space to sounder reasoning, for example on the compatibility of the different materials used or even on the appropriateness to dispose a junction at that place in the object.

To summarize what discussed above, an observation could be done, that differentiated waste collection may be a way to introduce learners to the practice of materials and their use in objects. This drives our imagination quite naturally towards design, which can be defined in a number of ways, yet is well beyond our objectives to go deeper into these considerations. However, a useful observation in a simple educational, and therefore divulgation-oriented, case, is recognizing that "good design is as little design as possible" (Swan and Luchs 2011). This allows making a connection with the existence of an instinctual design, to which Bruno Munari dedicated the Golden Compass to the Unknown Designer. This would mean reflecting on the experimental evidence that a simple design process exists, able to produce objects, which "work" perfectly nevertheless: an example of these objects can be the pencil, viewed as a composite of a graphite-argyle composite bar encased in a wooden cylinder (Belardi and Nowak 2014).

The former considerations imply two aspects, not completely disconnected between them, that the object produced is adapted to its function and that it is perceived to be likeable, therefore a "bond" with its user can be created in the longer run. To assess how the material can be employed and moulded in objects in order to improve its pleasantness and its value, therefore according to its "personality", a practice can be put to place, which is based upon the fact that learners acquire first-hand knowledge of the material characteristics, starting from their perception and the sensations and emotions they communicate to them: this is defined as "material tinkering" (Parisi et al., 2017). The "personality" of the material can be described for example through the respective proximity or distance to couples of opposite adjectives, such as in the studies by Karana et al., (2009). This outlines a fact not always considered in the discussion over materials, namely that, in a number of cases, all five senses are involved in the user interaction with these, which is considered as an effective strategy to learn to use materials in design (Ferrara & Lucibello 2012). In this sense, the interaction with the particular material constituted by waste is particularly critical, in that it starts at an early age and is filled sometimes with psychological sense of rejection. On this aspect, a reconnection is possible with the experience accumulated in the views expressed by Bruno Munari about "Pre-books", made for children not literate yet, hence in age 3-5 (Campagnaro 2016). An example of pre-book for education on expressive use of waste is depicted in Figure 1, dedicated at children of an early age, in the understanding that education about waste use needs to start as soon as possible.

Another aspect, which is embedded in this practice of material tinkering, is that learners at all levels can practice the experimental method and gradually refine their approach to the materials and their combination in the creation of innovative objects. This occurs since every experiment is supposed to teach you something, which might allow coming nearer to the objective, on one side, while on the other side it enables also better defining and outlining the goal in itself. Developing DIY materials from waste through material tinkering can mean therefore, before aiming at producing objects, acquiring experience from a sensory-expressive point of view of waste introduced into a self-produced matrix with a composition selected through a "trial and error" process. An example of the results obtained with this procedure, concentrating in the specific case on mandarin peels and on spent ground coffee, is offered in Figure 2. This can be considered suitable and appropriate in the evaluation of the corpus of characteristics of materials in their combination to form an object and with respect to the environment or setting in which they are supposed to be used. In this sense, it can be observed that the failure is as important as the success for the teaching that it brings to the experimenter (Orlandi 2010).

The experience on which this work is based is more targeted to children in the primary school age range; therefore it is more based on the first phase of acquisition of experience on waste-based materials, than it is on the following one, which involves the production of design objects. As the consequence, it is supposed they have no clear idea of what "design" can be, a significant difference with respect to experiences carried out in groups of design students. On the other side, it is important to consider that, given the target of the experiment, what is perceived as the instinctual approach to design, which appears to be present in every human being, becomes important and will be investigated more into depth in the following sections. However, in the age range selected, children are already able to make some simple measurements and are well familiar with some basic concepts, such as ingredients, weight, temperature, cooking time, mixing and moulding, so that the experience can start from these, which form the basis of reasoning for experimental procedure.

2. Design of the experience

This experience was developed based on the knowledge of children in a primary school age about materials sustainability, which is frequently introduced through the divulgation of the 3R (Reduce-Reuse-Recycle) strategies, building on the familiar experience about differentiated waste collection. The primary school children participating in the experience at Explora were taking part to the summer campus organized in the structure, as an initiative aimed at integrating their school formation and were coming from different classes located in the semi-central area of Rome, defined as the Flaminio district. The first examples of environmental education through the 3Rs date back to the early 90s, yet pose clearly an evident emphasis on the last R, that of "recycle", which is on the other side more related than the others to industrial production (Boerschig & De Young, 1993). If the industrial practice of materials recycling represents the main drive towards a sustainable society, a number of problems to introduce it in children education can be posed, starting from the fact that recycling can be perceived, quite rightly in most cases indeed, as something extraneous from their experience and to be studied theoretically rather than experimented. In particular, it is surely not desirable that primary school children interact at a higher level with plastic waste by re-shaping it softening with temperature or even leading to molding it. These possibilities are even a well-known reason for concern in societies where the activity of children collecting waste is widely diffused (Ensing 2010). In more practical terms, experiments with plastic waste can be carried out by cutting end-of-life plastic objects in fragments, taking care about the presence of plastic powder and in most cases avoiding that the children themselves would cut the objects into fragments, rather providing the latter ready for use already. This kind of workshops is successful in terms of becoming aware of the expressive potential of plastic fragments, for example in terms of mixing different colors. However, it is obvious that the interaction that the child can have with the material is very limited, being confined to sight, in the understanding that even touching plastics gives very repetitive sensations, since the only ones suitable for workshops, such as PET from plastic bottles, are mostly soft and in any case have no texture, no gradual color change, etc. In general terms, the above considerations would suggest that children cannot really enter an industrial procedure of recycling end-of-life plastics.

In addition, a major concern appears so far to keep them as much as possible far away from a "playing with waste" perspective, a practice disappeared for a long time in most part of Europe, yet still current and diffuse for many children in developing countries, which leads to obvious worries in terms of hygiene and safety (Oke et al., 1999). In other terms, playing with waste can be perceived as a practice exclusively limited to those children living in settings where no purposely designed games are available: however, it is an instinctual way to learn, which bears some potential for young children education. As a matter of fact, apparently non-organized play items do appear to be widely diffused historically in toy design, such as it the case with Lego bricks, Erector set, etc., which can be re-arranged in many different ways, and create a substantial "bond" with children. This suggests that it is possible to re-interpret "playing with waste" by introducing in it significant design content, even if spontaneous: this could be a way to present design to children in an easy and recognizable way. In this sense, re-use of plastic would be more suitable as a paradigm for this purpose: in practice, waste can be perceived as an "end-of-life" material that is offered a "second chance", with the most possible respect for its nature, hence for the characteristics that made it useful for its first use. A typical example of this practice is offered in Figure 3.

Reducing waste can rather be a "philosophical" objective, more difficult to understand in the first instance in primary school context. However, children are possibly educated for example towards reducing food waste, at home or at school canteens, and from this can be built some awareness at reusing waste inevitably produced in these situations, such as e.g., banana peels or potato skins. In recent years, this waste has been collected as "organic" with increasing effectiveness and it is a kind of practice that children are likely to have experimented also at home, or even more frequently whenever for example their families are parts of focus groups (Refsgaard and Magnussen, 2009).

To recapitulate these considerations, a number of observations preliminary to the development of the workshops were identified as a brainstorming exercise. These are reported in the three following points:

- The first point is to clarify what we define as "waste". This would be translated in a practical presentation over upcycling, as opposed to recycling, as a strategy able to transfer "new value" to waste, which has basically none, since we lost any "bond" to it (Ward 2012). A crucial question at this point is: "How does a material/object become waste?". The answers can be different, although are likely to concentrate about the fact that waste is "useless", "serves no purpose", "broken" or similar. Once clearly defined "waste", a selection has to be made about the particular kind of waste that is going to be used in the experiment. The idea is to adapt the "zero km" paradigm to this situation, therefore using waste readily available on the premises, also to explain to the children the importance of disposing of waste locally and to imply that the sustainability of any event, such as the workshop itself, may be measured on a number of parameters, among which are the "zero waste production" and the "zero transportation costs for disposal" (Boggia et al., 2018).
- A second point is to create a sequence of operations that would work in the preparation of DIY material.

Here, a relation between materials, cooking and design can be identified. The experimental method is a series of operations necessary, disposed in a logical order dictated by experience. Its aim is to reach the maximum result with the minimum effort. As Munari suggests, the same method can be applied for both cooking rice with vegetables and to produce the pan to cook the rice itself, provided the sequence of operation is logical. Building on experience means to investigate and research on what has been done before: in this sense, finished and unfinished objects can both have significance, since they represent different stages of development of the same process (Guerra and Zuccoli, 2012). This requires a significantly long timeframe that may be not available in the case of a workshop experience. However, the importance of disposing of an effective recipe (ingredients and quantities) and procedure (recipients, time, temperature) needs to be emphasized.

- The third point to develop is that for children to understand the possibilities inherent to the material developed from agrowaste they need to interact with it possibly with all the five senses in the most complete way (Pedgley et al., 2016). This needs a discussion on what has been produced, and which kind of use is foreseeable for a material with these characteristics. To appreciate materials obtained from waste, which inherently to their acceptance in new objects and therefore in sustainability, a new aesthetics has been proposed, based on "personality" of the material rather than barely its functional use, which has been the object of specific recent studies (Ayala Garcia & Rognoli 2017).

Of course, the relation with design does appear far from immediate: however, it was considered a good opportunity the fact that different professionals, namely designers, material engineers and educators, follow this experience. Children need not to know the exact role of them in the first place, but the important consideration to be done is that everyone has a different "vision" over waste. In particular, designers may be concerned of the expressive-sensorial characteristics of the products obtained from it, materials engineers of the re-use of waste even in a powdery form, so that the material obtained would have sufficient structural characteristics to guarantee suitability for use, and educators would concentrate on the fact that from waste, therefore matter with no value, children would learn new practical skills about moulding, therefore giving shape to materials. Putting it more generally, this type of experimentation would allow children learning the experimental method in a simple and functional way. The interests of the three different professionals would then converge on the fact that waste represents a problem for the environment. On the other side, re-using it in new materials would represent a possibility to prospectively reflect on how waste would become a new opportunity, not hiding it, but rather exploiting its characteristics in a "learning through experience" approach, which is not necessarily concentrated on the single final object to be obtained, but rather on the process that allows selecting possibilities for waste use in object (Potter 2013, Potter and France 2018).

In Figure 4 a scheme is presented about the final structure of the experience, trying to summarize the three points discussed above.

3. Realization of the experience

The experience has been realized in two occasions, in July and September 2017, at Explora – Museo dei Bambini, in Rome, with children aged 8-11 (https://www.mdbr.it/evento/possibile-se-sostenibile/). Museo dei Bambini is a no-profit permanent Children's Museum located in Rome, on the area previously occupied by a tram depot, which is dedicated to children, schools and families, active from 2001. The structure offers opportunities of play, direct experimentation and hands-on learning, centered on children and their potential, proposing occasions of personal enrichment and sociality, and promoting the development of their cognitive and emotional skills. Coming to the experience, given the setting, it involved children mainly living in urban areas, therefore the idea was to introduce some waste easily found in this context, hence rather coming from a kitchen setting e.g., a school canteen, than from a real agricultural one. Children are followed in this experience by a team formed by professors of industrial design and of materials engineering, by junior researchers and designers and by educators from Museo dei Bambini, as suggested above.

In this case, the target was the production of "buttons" either for application on textiles, therefore provided with holes, or as covers to be glued to fridge magnets, therefore with no holes provided. In the former case, holes are provided by the insertion of toothpicks into silicone moulds. In particular, in both experiences, waste materials were used, such as carrot peel or tomato peel, dry parsley leaves or expired coconut powder, which have been mixed together in various recipes including agar or isinglass and glycerol as plasticizers, lemon juice as anti-oxidant, and some amount of water. The recipes have been provided by the researchers and the children were asked to experiment the preparation of the DIY materials. This involves a number of operations: weighing the ingredients, cutting these into pieces, when necessary, such as it is the case for isinglass sheets, then mixing and amalgamating and molding the material and placing it in silicone moulds, then cooking it according to the necessary time and temperature and extracting it finally from the mold, also referred to as "demolding", and allow it to dry and cool down until ready for use as buttons or magnets.

The experimentation has been articulated in three phases, elaborating from the concepts presented in Figure 4, therefore building on the fact that waste, through a sequence of operations, becomes a material. Design objects

are beyond that picture, of course, but this perspective gives suggestions to the possible realization of these, starting from the "target" of the experimentation, the button. More in particular, the phases, each one during around 60 minutes are:

Phase 1: Experiment of manipulation and "realization" of the material through a perceptive-sensorial experience useful to discover and "build" its identity, united to some short spots of more "theoretical" information on the theme and on the characteristics of DIY materials to be expected from agro-waste and on reasoning on their comparison with oil-derived plastics.

Phase 2: Analysis of the characteristics of self-produced materials in the experiment from an aesthetic and perceptive point of view through the sensorial experience, Through the observation and manipulation of samples realized in the previous phase, first the tactile properties, such as flexibility, softness/roughness, and the visual properties, such as color nuances and texture, which would particularly related to the different waste materials used, but bearing in mind that this would be analyzed as much as possible involving all the five senses, as suggested by Crippa et al., 2012.

Phase 3: Synthesis through brainstorming activities on suggestions that have resulted from the perceptive-sensorial experience, in relation to the possible uses of the material and its potential applications in design.

Figures 5-9 report schematically the different phases of the experience.

4. Discussion on the relevance of the experience for teaching design and sustainability in a primary school context

After carrying out this experience, thinking on how to repeat it and therefore reflecting on the information collected, discussion started from two considerations, essentially what the children appeared to have learnt from the experience and how this could be repeated in a larger timeframe and on different targets, for example being aimed at secondary school pupils.

The starting point of the experience were two questions, which were proposed as an introduction, namely "how can we help the environment to cope with materials?" and "what is design?". The answer to the first of the two questions is quite uniformly "recycling", whereas the second one shows some variations, between "drawing" to "producing nice objects". The answer to the former question is likely to indicate that children have mainly no idea of the fact that recycling produces not only advantages, but also significant drawbacks: the amount of material lost, the energy spent in the process and also some perceptive qualities, such as for example transparency of plastics. In contrast, the answers on design appear to demonstrate that it may be reasonably easy to show that everyone can be a designer, even (and especially) the children involved in the experience.

Previous experiences of material tinkering, though mainly conducted with design students, demonstrated that the difficulty to perceive upcycling as an everyday practice is real and that, on the other side, the link between upcycling and design is very strong, if not obvious, in the sense that design can serve as the "tool" that provides value to waste materials, which ultimately is the scope for upcycling itself (Santulli & Langella 2013). On the other side, upcycling can be intended either as an industrial practice or as a more experimental practice, which may intended as propaedeutic to the former or simply used as an investigations for the possibilities "embedded" in the upcycled materials (Sung 2015). As demonstrated from literature and from the tradition based on Munari's approach, the metaphor of cooking as a link between the experimental method and design appears to work. This has been experimented also in other situations, where cooking is even inserted in a more multidisciplinary approach, such as in Laurence Humier's experience for example, contaminating molecular gastronomy, design and chemical engineering, with the consequence that ingredients are selected to produce effects similar to those experimented in kitchen practice (e.g., pseudoplasticity of mayonnaise) (Rognoli et al., 2015).

The final discussion during the experience evidenced that there is great interest for "breaking unwritten rules", such as the fact that buttons need to be round-shaped, whereas on the other side nuances of colour are rather accepted, yet there is some drive towards obtaining particular colour mixtures. Extending these concepts to longer timeframes, involving different meetings, which will progressively verify the results obtained, first a stricter application of the experimental approach could be implemented, by testing and improving, or rather better focusing, recipes and procedures to produce DIY materials. Moreover, also on the design side improvements would be provided, since it would be possible to proceed to the optimisation of these materials for the possible production of object, which would be more personalised, such as it is the case of DIY material pieced exposed in Figure 10. In practice, the possibilities of DIY materials unveiled their identity, yet of course this could not be attained in these experiences, yet the intervention in the final discussion of the designers would clarify that these materials could have concrete possibilities, aimed for example to their customisation in terms e.g., of aromatisation (Galentsios et al., 2017). The identity of these materials realised starting from food waste would be revealed to be strictly linked with the physical and sensorial contact. It has been noticed already that a different aesthetical perception would be required for that, in particular the material would appear unfinished, raw, an element that represent a defect for some typologies of products, but that on the other side, when

associated to the richness of our interaction with them, could give strength and added value to the product (Rognoli and Karana 2014).

One can associate in practice the biodegradability not to their gradual disappearance and possibly composting, as the material practice usually does in recent times, not considering that this process concerns the material ground back to powder, yet may associate it with them being alive, therefore in a continuous evolution, and able to communicate. This is also why fields such as bijouterie may be interested to these materials, as suggested above. In more general terms, DIY materials would allow speaking to the children about the emergency of new uses and needs, requiring objects with an accelerated lifecycle, yet not to be intended as "use and throw", such as it is the case for smartphone covers, for example. It has also been observed elsewhere as in emerging design the focus tends to shift from 'objects' toward 'ways of thinking and doing', therefore more than producing a series of objects it would be important to be clear about the approach followed to obtain it and therefore its profound meaning (Manzini 2015). In the specific case of this work, it is important to clarify whether the biodegradability of the possible objects produced acquires a sense, as this experience allows discussing with children also of the relation between "bond" with an object, such as a toy, end of life and therefore environmental impact, coming back circularly to the problem of waste, which is likely to become more and more central to their life experience.

5. Conclusions

Material tinkering from waste with children in age 8-11 was considered propaedeutic to the introduction of these concepts in school teaching, as a "learning from doing" practice. This involved starting from the instinctual or only lightly organised knowledge of children of that age on differentiated waste collection, in particular the organic fraction. Building on this basic and day-by-day familiarity with "waste", by using the metaphor of cooking, as from Bruno Munari's example, design was also introduced and discussed. The interest of this experience was the limited timeframe, which needed to limit the application of the experimental method to what strictly necessary, but nonetheless produced significant learning experience and allowed discussing the event in a final brainstorming. In practice, the possibilities of simple DIY objects produced (buttons) unveiled the identity of materials and their possibilities for design in terms of expressive-sensorial characteristics, involving as much as possible all the five senses in the evaluation of the material.

Future research directions will involve linking more strictly "material tinkering" to its social significance. In other words, a limitation in this experience, which was due also to time constraints, has been in the fact that waste collection and classification has not been discussed together with children, yet has been given as a precondition for operating the experience. It needs to be clarified that the production of objects is only a tool to experiment methods for improving the social value of upcycling "waste". This would result in a gradual process of gaining consciousness about the potential of instinctual design in identifying a correct scenario for these practices. Of course, a longer timeframe would be needed to identify more precisely what is the social and functional sense that children attribute to waste upcycling.

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References

Ayala-Garcia, C., Rognoli, V., (2017) The New Aesthetic of DIY Materials, The Design Journal, 20, S375-S389.

Boerschig, S., De Young, R., (1993), Evaluation of selected recycling curricula: educating the green citizen, The Journal of Environmental Education 24 (3), 17-22.

Bramston, D., Maycroft, N., (2014), Designing with waste, in: Materials Experience. Fundamentals of Materials and Design, Karana, E., Pedgley, O., Rognoli, V., (eds.), Butterworth and Heinemann, 2014, 123–133.

Belardi, P., Nowak, Z., Why Architects Still Draw, MIT Press, 2014.

Boggia, A., Massei, G., Paolotti, L., Rocchi, L., Schiavi F. (2018), A model for measuring the environmental sustainability of events, Journal of Environmental Management 206, 836-845.

Campagnaro, M. (2016), The function of play in Bruno Munari's children's books. a historical overview, Journal of Theories and Research in Education 11 (3), 93-105.

Charter, M., (1998), Sustainable Product Design in: The Durable Use of Consumer Products in: Kostecki, M., (ed.), Springer, New York, 57-68.

Chawla, K.S., Rajaram, V., (2016) Reduce, Reuse, Recycle, in: Integration of Nature and Technology for Smart Cities, by Ahuja, A. (ed.), Springer, New York, 269-282.

Corsi, M., (2002), The child friendly cities initiative in Italy, Environment&Urbanization 14 (2), 169-179.

Crippa, G., Rognoli, V., Levi, M., (2012), Materials and emotions. a study on the relations between materials and emotions in industrial products, Proceedings of 8th International Design and Emotion Conference London, Central Saint Martin's College of Art & Design, 11-14 September. Edited by J. Brassett, J. McDonnell & M. Malpass Ensing, A., (2010) Child Labour in an Urban Setting: Markets and Waste Collection in Lima, in: "Hazardous Child Labour in Latin America", Springer Dordrecht, pp. 21-42, ISBN 978-94-007-0177-9.

Ferrara, M., Lucibello, S., (2012) Teaching material design. Research on teaching methodology about materials in industrial design, Strategic Design Research Journal 5 (2), 75-83.

Galentsios, C., Santulli, C., Palpacelli, M., (2017) DIY bioplastic material developed from banana skin waste and aromatised for the production of bijoutry objects, Journal of Basic and Applied Research International 23(3), 138-150.

Guerra, M., Zuccoli, F., (2012) Finished and Unfinished Objects: Supporting Children's Creativity Through Materials, Procedia - Social and Behavioral Sciences 51, 721-727.

Hopewell, J., Dvorak, R., Kosior, E., (2009) Plastics recycling: challenges and opportunities, Philosophical Transactions of the Royal Society B: Biological Sciences 364, 2115–2126.

Karana, E., Hekkert, P., Kandachar, P., (2009) Meanings of materials through sensorial properties and manufacturing processes, Materials & Design 30 (7), 2778-2784.

Oke, M., Khattar, A., Pant, P., Saraswathi, T.S., (1999), A Profile of Children's Play in Urban India, Childhood 6 (2), 207-219.

Orlandi, A.E.C., (2010) Experimental experience in design education as a resource for innovative thinking: The case of Bruno Munari, Procedia - Social and Behavioral Sciences 2 (2), 5039-5044.

Parisi, S., Rognoli, V., Sonneveld, M., (2017), Material Tinkering. An inspirational approach for experiential learning and envisioning in product design education, The Design Journal 20, Sup. 1, S1167-S1184.

Pedgley O., Rognoli, V., Karana, E. (2016) Materials experience as a foundation for materials and design education, International Journal of Technology and Design Education 26 (4), 613–630.

Potter, P., (2013) Technologists talk: making the links between design, problem-solving and experiences with hard materials, International Journal of Technology and Design Education 23 (1), 69-85.

Potter P., France B. (2018) Informing a pedagogy for design and problem-solving in hard materials by theorising technologists' learning experiences, International Journal of Technology and Design Education 28, 101–120.

Refsgaard, K., Magnussen, K., (2009) Household behaviour and attitudes with respect to recycling food waste – experiences from focus groups, Journal of Environmental Management 90 (2), 760-771.

Rognoli, V., Bianchini, M., Maffei, S., Karana, E., (2015), DIY materials, Materials & Design 86, 692-702.

Rognoli, V., Karana, E., (2014) Toward a New Materials Aesthetic Based on Imperfection and Graceful Aging, in Karana, E., Pedgley, O., Rognoli, V., (2014) Materials Experience. Fundamentals of materials and design, Elsevier.

Santulli, C., Langella, C., (2013) '+ design–waste': a project for upcycling refuse using design tools, International Journal of Sustainable Design 2 (2), 105-127.

Sung, K., (2015), A review on upcycling: current body of literature, knowledge gaps and a way forward, The ICECESS 2015: 17th International Conference on Environmental, Cultural, Economic and Social Sustainability, Venice, Italy, 13-14 April 2015.

Swan, K.S., Luchs, M., (2011) Product Design Research and Practice: Past, Present and Future, The Journal of Product Innovation Management 28 (3): 321–326.

Ward, S.P., (2012) 'Breathing life into the corpse: upcycling through adaptive reuse', from: "Designing for zero waste: consumption, technologies and the built environment", Earthscan, Oxon, England, 247-266.Lawrence, S. et al. (2001). Persistence of Web References in Scientific Research. *Computer*. 34, 26-31. doi:10.1109/2.901164, http://dx.doi.org/10.1109/2.901164

Smith, Joe, (1999), One of Volvo's core values. [Online] Available: http://www.volvo.com/environment/index.htm (July 7, 1999)

Strunk, W., Jr., & White, E. B. (1979). *The elements of style.* (3rd ed.). New York: Macmillan, (Chapter 4).

Van der Geer, J., Hanraads, J. A. J., & Lupton R. A. (2000). The art of writing a scientific article. *Journal of Scientific Communications*, 163, 51-59

Figure 1. Lab pre-book (Lib-lab) for small children on waste recognition
(courtesy of Valeria Urriani, Università di Camerino)

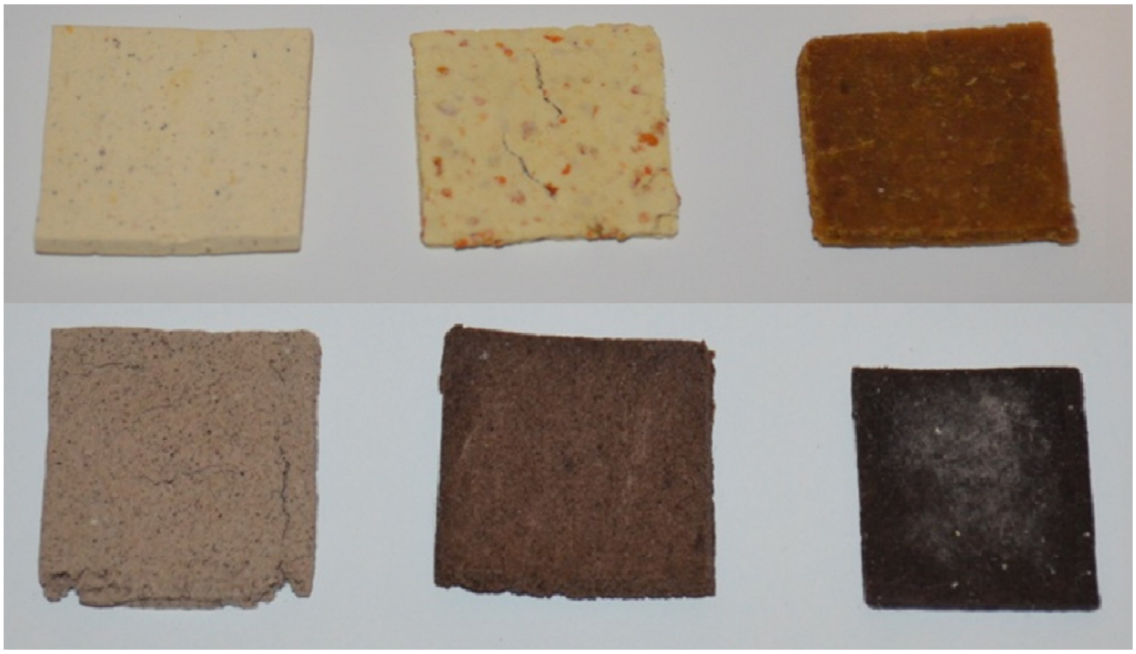

Figure 2 Six examples of DIY materials (B.I.O.) obtained through self-developed recipes including waste, namely mandarin peels (above) and spent ground coffee (below)
(courtesy of Lucia Borroni, Università di Camerino)

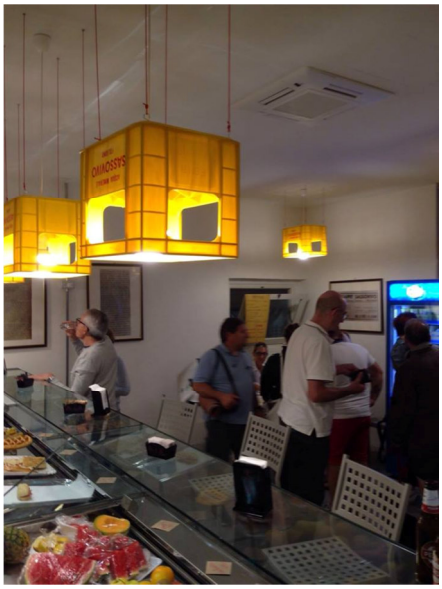

Figure 3 Example of re-use of six-water bottles carriers in polypropylene from the 60s (courtesy Fonti di Sassovivo, Foligno)

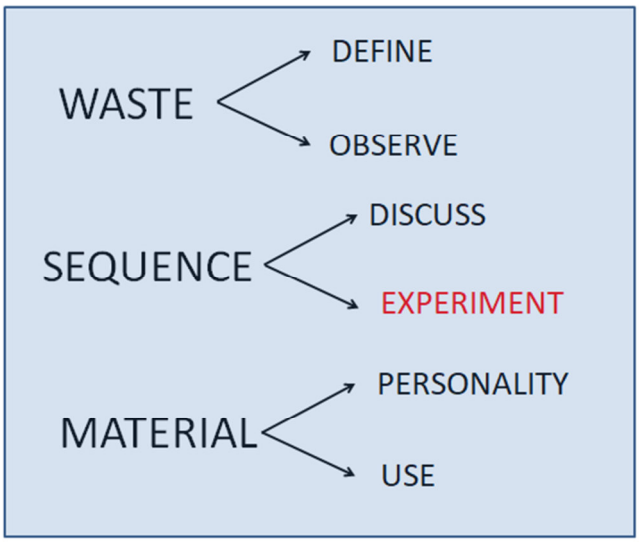

Figure 4 Scheme of the experience according to the essential keywords

Figure 5 Initial phase of preparation taking the different ingredients and accessories

Figure 6 Mixing in silicone moulds after having weighed the ingredients and cut the isinglass sheet

Figure 7 Weighing the mixed material for a sample button

Figure 8 A specimen, with carrot peels and parsley, has been demoulded and is ready: first visual observation

Figure 9 Final discussion with children involved in the workshop

Figure 10 DIY material pieces colored with natural colors and textured for bijoutry objects (courtesy of Federica Voltattorni and ITT “Allievi-Sangallo”, Terni)