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Cooking STEAM: A Case Study on Establishing a STEAM Learning Community using a Performative Framework and Cooking

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Abstract. The work reported in this paper is informed by PerFECt, a performative framework supporting collaborative learning and creativity that addresses issues related to the effective use of digital technologies to establish and sustain learning communities. Its core principles are reinterpreted to implement unplugged collaborative learning activities to creatively explore sciences, technology and mathematics with special emphasis on the core principles of algorithmic design by presenting recipes in the form of flow diagrams. By presenting the execution of algorithms within a drama-based (theatrical) framework many creative explorations are offered within the so called STEAM education. The adoption of playful activities that put the children's bodies in motion is well aligned with pedagogical approaches that emphasize embodied knowledge and performance and open up opportunities for deeper personalized learning experiences that promote inclusion of children from different cultural backgrounds.

Keywords: cooking, STEAM, flow diagrams, algorithms.

1 Introduction

Seymour Papert, a pioneer of educational informatics, has emphasized the need to give opportunities to children to become better learners through computer coding. In his seminal book "Mindstorms: Children, Computers and Powerful Ideas" he presented the big ideas behind computers and how these big ideas can be better understood by young children [1]. In later works, Papert expressed his disappointment that readers of this book that subsequently tried to put its vision into action through their teaching, focused too much on the word "computers", paying less attention to "powerful ideas". Today, with the advent of educational robotics, STEM/STEAM teaching and the implementation of world-wide initiatives to promote coding such as the Hour of Code and EU Week of Code [2] [3] the danger of overemphasizing the use of computers without paying the necessary attention to the powerful ideas behind them, is even bigger.

The issue becomes even more important when it comes to younger children at the first grades of primary school or even kindergarten. There is already a plethora of related apps and robotic kits available for children at these ages. Consequently, there is a temptation for teachers to focus on the technical part of educational informatics instead of trying to emphasize the technology independent big ideas of computing so that young children could deeply understand and effectively use digital technologies throughout their lives.

The work presented in this paper tries to address all these concerns on overemphasizing the technical aspects of computers in education by putting an explicit focus on powerful ideas related to the mathematical foundation of computer science and trying to offer engaging learning activities for children to understand these ideas even without using actual computer equipment. This is in line with an interesting approach to educational informatics termed "Computer Science Unplugged" [4]. To make the unplugged activities more interesting and engaging, we employ ideas from the TIM methodology that links mathematical teaching and learning with theatre in education. The methodology is developed and promoted by the Erasmus+ project TIM – Theatre in Mathematics (https://www.theatreinmath.eu/). The resulting learning framework is titled "Cooking STEAM" and supports the creative exploration of algorithms in the form of flow diagrams to represent cooking recipes combined with drama-based performances to present the recipes from a professional cook combined with artistic interventions employing music, dancing and storytelling.

The overall approach is based on PerFECt, a design framework that emphasizes performativity, i.e. that knowledge is based on human performance and actions done within certain social contexts, rather than development of conceptual representations. This framework has already been used to guide the developments on several projects addressing digital heritage preservation and creative learning [5] [6]. In the work reported in this paper, the PerFECt framework is re-interpreted and re-used to focus on the idea of de-design. De-design addresses the need to put emphasis on leaving out features from a design in order to give more freedom to the users of a certain system [7]. In the case of the Cooking STEAM activity, de-design is used to offer an alternative to using digital tools for the representation of algorithms.

The rest of the paper is organized as follows: Section 2 presents the design principles of the PerFECt framework that are employed in the development of Cooking STEAM. Section 3 presents its rationale while section 4 presents its design and how flow diagrams are used to represent recipes as algorithms. Section 5 presents major conclusions.

2 Design principles adopted from the PerFECt Framework

Technology in general and digital technologies in specific is a catalyst for establishing and sustaining certain social structures [8] within which End users are becoming "producers" of contents and functionalities. The term expert user is suggested in [8] to signify an expert in a particular domain with main goal to develop the technological capabilities available on that domain. An expert user engages in creative/authoring activities without being a professional software developer. Usually the role of end user and that of an expert user are played by different people that may also belong to different communities. Furthermore, [9] suggests the role of meta-designer to describe the work done by professionals who create the socio-technical conditions for empowering end users in operating as active contributors of contents and functionalities.

A meta-designer creates open systems that can be further developed by their users acting as co-designers. However, apart from the technical conditions necessary to set up such environments, there is a need to effectively create the social conditions that will allow expert users to build and adapt the artifacts to be used by end users. In respond to this need, a special user role is specified: maieuta-designers. A maieuta-designer creates the necessary preconditions for facilitating expert users appropriate the design culture and technical notions necessary for the meta-task of artifact development and involving as many end users as possible in the process of continuous refinement of the artifact, by improving participation. The use of the term "maieuta" directly references the Socratic method of getting people acquire notions, motivations and self-confidence to undertake challenging tasks.

End users, expert users, meta-designers and maieuta-designers engage in certain interactions with each other as well as with the digital artifacts and tools causing the emergence of a co-evolution phenomenon. Meta-designers focus on designing and providing the most effective tools that may sustain the co-evolution between end users and expert users. Maieuta-designers facilitate the transition from the role of end user to the role of expert user thus empowering people to appropriate and contribute to their digital artifacts. If certain end users are not interested or fail to move towards the role of expert user, maieuta-designers may facilitate system evolution by systematizing the reporting of opportunities or shortcomings, as identified by end users, and proposing solutions handled by expert users or even suggest further technological contributions from meta-designers. All the concepts presented above constitute the building blocks of the PerFECt framework as depicted in the figure below.

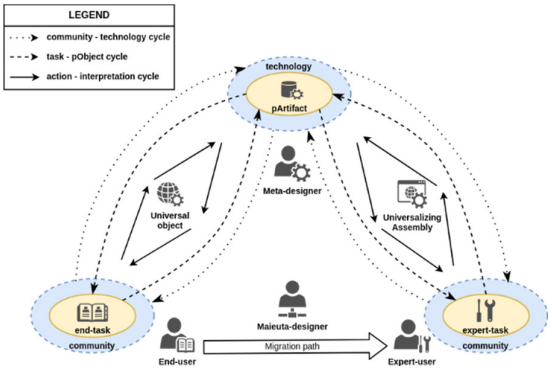

Fig. 1. The main components of PerFECt framework

The interplay among the four roles of the framework give rise to two co-evolution processes as depicted in Fig. 1: The first one refers to the use of software devoted to the end user where there is continuous (cyclical) interaction between the end user and the system. This is depicted in Fig. 1 (left) with three homocentric cycles of arrows that represent the action-interpretation cycle at the lower level, the task-object cycle at the middle level and community-technology cycle at the upper level. In an analogous way, there is a second cyclical process depicted in Fig. 1 (right) that refers to the use of software devoted to expert user as building blocks of the system in continuous evolution. This process corresponds to yet another set of three homocentric cycles of the same nature: action-interpretation, task-object, and community-technology layers.

The inner interaction cycle in each co-evolution process refers to actions (triggered by the corresponding user or software) that are interpreted by the other party (soft-ware or user respectively). The task-object cycle in the middle refers to the co-evolution of the user task and the corresponding artifact within the boundaries of the System. Finally, an outer community-technology cycle captures the idea that the overall environment within which a user is working (community), co-evolves with the technology that supports the operation of this environment.

The PerFECt framework employs the notion of universality to addresses the issue of causality in digital representations, as Brenda Laurel puts it in her seminal book "Computers as Theatre" [10]: *"… an action is universal if everybody can understand it, regardless of cultural and other differences among individuals… Aristotle posits that any action can be "universalized" simply by revealing its cause; that is, understanding the cause is sufficient for understanding the action, even if it is something alien to one's culture, back-ground, or personal 'reality'."* (p. 94). Consequently, within the PerFECt framework, the meta-task of expert users is to enable a universalization of physical objects by exploiting the available tools in the form of performative artifacts (pArtifacts) to account for the incorporation of the idea of performativity.

The concept of performativity, as exposed in [9] emphasizes the fact that human behavior can be understood and analyzed by assuming that all human practices are performed so that actions can be seen as a public presentation of self. This is the conceptual

basis of the methodological breakthrough titled the performative turn in cultural studies, social sciences, humanities and design. The term turn signifies the trend to reverse the ontological premises that reality corresponds to particular objects, entities, and configurations that exist in and of themselves exhibiting certain essential qualities towards a new central hypothesis that objects are textures of partially coherent and partially coordinated performances existing through multiple situated practices. Meaning making is essentially a social process. Knowledge is created through the actions of the members of a social structure. In this respect, there is a shift towards "the active social construction of reality rather than its representation" [11].

The roots of this approach can be attributed to the need to move beyond the prevailing focus on texts or symbolic representations to capture meaning. Performance is, above all, a meaning making bodily practice. Consequently, it is related to rituals and other forms of spectacles and social practices [12]. Beyond the main premises and the theoretical justification of the validity of performativity, one could attribute the significance of this paradigm to an inherent dramatic quality of human experience.

3 Rationale of the Cooking STEAM activity

A major issue that arises is the effective integration of people of diverse cultural backgrounds in a way that facilitates intercultural dialogue and creative use of diverse traditions that promotes human values and, hence can boost creativity and develop opportunities for innovation and new jobs for youth. Cooking STEAM addresses these challenges by identifying food, cooking, music and dancing as key aspects of different cultures by explicitly focusing on activities that encourage active citizenship, intercultural dialogue, while at the same time promoting the well-being of youth as well as its potential to develop critical skills and creative spirit to facilitate career pathways.

An important aspect of food as an accelerator of cultural identity is related to how diverse cultural communities try to preserve their eating habits, music and dancing traditions as part of their connection with their culture. However, due to the challenges that creative arts organizations, institutions and enterprises currently face, some aspects of the art and traditions of cooking as well as the creative arts risk being lost or abandoned. As a result, those sectors need to be reinforced and become resilient through new innovative and creative approaches, encouraging the participation of young people, educators, voluntary leaders, creative practitioners, and cooking experts.

Approaching food, music and dancing as important aspects of cultural identity, Cooking STEAM explores the traditions of European hosting countries and of countries of origin of migrants, to promote creativity, cultural awareness, STEAM learning (food and eating traditions integrate elements of physical sciences, chemistry, biology, technology, arts) and creative dialogue by combining the fields of STEAM with cooking, music and dancing.

Cooking STEAM employs an approach based on playful, creative learning activities that are offered to youth leaders, youth volunteers and educators, including youth clubs, industry and academia, as well as creative practitioners, food ambassadors and cooking experts. These also inspire them to develop their own learning pathways, together with

their learners and their families. To this end, important aspects of the food culture are explored refer to the special ingredients of recipes that depend on the physical environment of the respective countries (like special plants and fruits), their myths and nutritional importance.

Cooking STEAM links tradition and technology to enable the development of important life skills for youth regarding chemical and biological parameters of food resources, their nutritional properties and preparation techniques. All the materials and learning scenarios are integrated in a community building and support framework (i.e. the PerFECt framework) that enables effective diffusion and reusing, to enable creativity and intercultural dialogue in the form of combined dishes, diets and eating contexts. Additionally, an interesting aspect of foreign language learning refers to name of ingredients, numbers and arithmetic/fraction and in the semiotic domain of cooking, with relation to recipes that provides an opportunity for local and migrant learners to learn a rich vocabulary in foreign languages and exercise their learning achievements during the collaboration with native speakers.

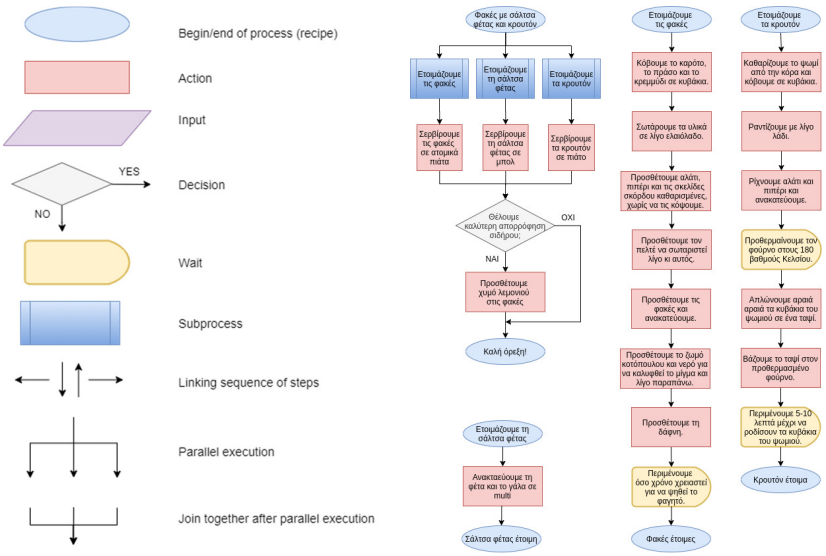

Fig. 2. The graphical components employed to represent recipes (left) and an example of a specific recipe (right).

4 Cooking STEAM Sessions Design and Algorithmic Representation of Recipes

Each Cooking STEAM session is organized into three parts:

1. Playful and artistic introduction (10-15 minutes) with narration and song or dramatized narration with a puppet. This part incorporates, on a case-by-case basis, information on selected local diet, reading nutritional information of products, etc.
2. Presentation of a recipe with a flow diagram and execution. In the end the children taste the food which, if it requires a lot of preparation time, has already been prepared in advance. During the execution and serving, the children discuss with the cook about the ingredients and their value, the cooking methods and whatever other questions they have. This interactive part has great potential and gives the opportunity for further discussion of ideas and concepts presented in the first part. The participation of children is particularly strong.
3. Mathematics / computer / science activities in the form of small exercises.

Fig. 2 above presents the components used to represent the recipes as flow diagrams (left) and an example of a specific recipe employing these components.

Cooking STEAM captures and uses the main components of the PerFECt framework as it is presented in section 2: When children are cooking following a recipe (or watching the cook enacting a recipe) they are essentially end users (in the terminology of the framework) that just need to follow certain rules with consistency. When children are creating their own versions of the recipe guided by a facilitator (this is the maieuta-designer in the PerFECt framework) to explore and gradually develop their skills in cooking, they are essentially in transition to become expert users, as the PerFECt framework suggests.

A very interesting aspect on how Cooking STEAM interprets the PerFECt framework and sheds new light on its applicability in designing collaborative learning experiences, is related to the idea of de-design [7]. De-design evokes the idea that omitting and leaving out features from a design is just as critical to the success of a system as it is including them positively. This is connected to the fact that any feature does both afford and constrain interactions with and through the artifact, what is left out of it has the potential to be even more important than what designers put in it on purpose. This is a disciplined inaction that is intentional and goes beyond mainstream design approaches by offering opportunities for different interpretations of the information that need to be considered in user practices, and recognize the creative power of ambiguity. The relevance of de-design to learning and creativity, is thus evident.

Following a de-design approach, Cooking STEAM, takes the idea of universality, as used in the PerFECt framework, along with the underlying concept of causality, and uses it beyond digital technologies to account for a human body (or a constellation of human bodies) that behaves under certain rules. This way, the cooking activity uses the human body as a kind of a robot, following certain instructions to realize a recipe. Extensions of the basic recipe, can give rise to alternative rules so that the participating children could creatively explore new situations and representations. In summary, Cooking STEAM generalizes the notion of universal objects and universalizing assemblies (Fig. 1) to account for any kind of object that can follow well-known rules and corresponding constellations of such objects.

5 Conclusions

The work reported in this paper is informed by PerFECt, a performative framework supporting collaborative learning and creativity that was initially developed to capture design principles suitable for the development of open learning environments [13] to effectively support collaborative learning [14] emphasizing the need to link learning to effective social structures. Consequently, this framework addresses issues related to the effective use of digital technologies to establish and sustain learning communities. The framework is also applicable in the analysis of serious games [15] and cultural heritage systems [16] as important means to foster engagement and creativity in learning. Its core principles, as discussed in this paper, can also be employed to implement unplugged collaborative learning activities. This is the case of Cooking STEAM to creatively explore sciences, technology and mathematics with special emphasis on the core principles of algorithmic design by presenting recipes in the form of flow diagrams.

Cooking STEAM departs from the usual conception of Computer Science Education that assumes the mandatory use of electronic computing devices including robots, physical computing devices etc. Although all these devices convey an important perception of special purpose programming languages that can help learners understand the importance of computer coding and its potential for cultivating creativity, they cannot capture the universal nature of algorithms and help the students understand the algorithms can be found everywhere around them, wherever a certain language is used to describe in a rigorous way any kind of process. By presenting the execution of algorithms within a drama-based (theatrical) framework, Cooking STEAM offers a sound ground for many creative explorations that help children get familiar with their bodies and physical materials. Such embodied knowledge approaches open up opportunities for deeper personalized learning experiences [17] [18] [19] possibly combined with flipped teaching of mathematics [20].

A systematic evaluation of the presented approach remains to be done. A pre-pilot implementation was done with limited time duration and participation due to the restrictions imposed by the COVID-19 pandemic. The qualitative feedback from the participants was extremely enthusiastic. This pre-pilot focused on Cretan Diet recipes and the use of local products in the preparation of meals and was linked to computer science lessons that developed simple robotic constructions that were used during the Cooking STEAM activities.

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Within the context of the MAKER SCHOOLS: Enhancing Student Creativity and STEM Engagement by Integrating 3D Design and Programming into Secondary School Learning (project number 2020-1-BG01-KA201-079274) funded by the Erasmus+ programme, several tangible 3D objects are designed and printed to facilitate the implementation of Cooking STEAM learning activities and the engagement of participants in the creation of tangible flow diagrams.

The design and Implementation of the Cooking STEAM activities was done in collaboration with Maria Archontaki (animator), Stefanos Archontakis (chef), George Gypakis (musician and educational musical instruments maker), George Kiskoukis (musician), Alkis Bakaros, Lazaros Charalampidis and Chrysovalanti Mariolou (computer science teachers). The pre-pilot implementation was done in Theodoropoulou Schools (https://theodoropoulou.gr/el/news/view/12526) within their summer activities programme in 2020.

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