DIST-M: computer-based collaborative script to mediate the argumentation in mathematics

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This thesis is part of a research that aims to understand whether it is possible to use, in the context of mathematics education, an e-learning platform to implement a teaching methodology based on mediation and peer interaction (Vygotsky, 1980). We want to investigate whether, and to what extent, it is possible to transfer the role of mediator, classically assumed by the teacher, to the online peer group, supported by the platform. This research has led to the definition of a design methodology for competence-based mathematics learning in e-learning environment, we named Digital Interactive Storytelling (DIST). It is based on the assumption that such environment can be arranged in a way that a good exploitation of platform tools and a well-structured collaboration among peers can act as an expert support to students in achieving their learning goal (Dello Iacono, 2015; Albano, Dello Iacono, Mariotti, 2016; Albano, Dello Iacono, Fiorentino, 2016). The underpinning theoretical approach is frame in the socio-constructivist view of learning, where students construct their own knowing at beginning being actively engaged in social interactions and then internalizing it (Vygotsky, 1980). The DIST-M consists in collaboration scripts, aimed at regulating and structuring roles and interaction in a collaborative setting (King, 2007). As suggested by the name, the described methodology is implemented in a storytelling framework, where the students is a character of a story and she should interact facing problems, whose solution is needed to go on. Such choice on one hand can motivate learners and on another hand can have benefits of the integration between narrative and logical-scientific thought (Zan, 2011). The DIST is organized as a collection of various Frames. Each Frame is a collection of scripts, each of them consisting of one or more tasks, where a task is defined as an atomic learning activity. The first Frame is called Introduction and it aims to familiar the student with the DIST and the story and with the computer-based tools to be used. All the other Frames are labelled as "Frame of level" since they aim to mediate various levels of the specific competence at stake. This means that there will foresee a Frame of level 1, that mediates a basic level of competence, a Frame of level 2, mediating the same competence at a higher level, and so on.

The task can be individual, collaborative or mixed. In the individual tasks, the student work alone and she is required not to communicate with her peers and to deliver her work individually. In the collaborative tasks, the student is expected to share the work and the delivery with her peers by using the tools available in the platform (chat, forum, wiki, etc.). In the mixed tasks, the student can communicate with her peers (usually by chat) but she deliveries her work individually. The script has been designed as sequence of collaborative and individual tasks so that learning is first socialized and then interiorized, according to a Vygotskian view (Vygotsky, 1980). When a DIST concerns a mathematical competence, it will be called DIST-M, that means Digital Interactive Storytelling in Mathematics.

In this thesis we present an instance of DIST-M designed and implemented for a specific case study focused on argumentation and communicative competences in mathematics. As shown by PISA outcomes, a critical and challenging aspect of PISA tasks is the requirement of expressing arguments and conclusions in written form (Turner and Adams, 2012). In the frame of discursive approach to mathematics learning, seen as initiation to a particular mathematical discourse (Sfard, 2001), Ferrari (2004) shows that mathematical language and

written literate registers of ordinary language share many features. Thus, he concludes that being familiar with written literate communications is a prerequisite to promote advanced mathematical thinking. To this aim, there is a need of a shift from the request of just solving a problem to the request of verbal explanations. This is why we have focus the DIST-M presented in the thesis on the construction of arguments written according to a register shared in the mathematical scientific community.

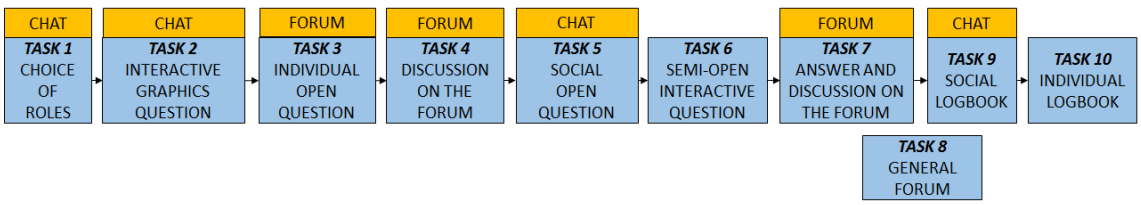
We have implemented the DIST-M in the e-learning platform Moodle (https://moodle.org). It is an environment for modular learning which offers various collaboration tools we have used: Chat, Forum, Wiki, Lesson, Task. Moreover, concerning the digital storytelling frame of the DIST-M, we have used comic strips, by means of the tool Tondoo (www.toondoo.com - online environment for creating comics) to implement the story, as they allow a direct and immediate link between words and images, promoting the learning process as it appears less hard and more enjoyable (Marrone, 2005). Finally, the interactivity given by the possibility of manipulating objects has been realized by means of the dynamic mathematical software GeoGebra (www.geogebra.org), as programming language in order to implement interactive applications integrated within Moodle pages.

For the implementation of DIST-M three kinds of new resources have been defined, that are Tutorial, Interactive Graphical Question and Interactive Semi-Open Questions.

The Tutorial is an interactive application that provides for the interaction of the student with a interactive object (graphs, text boxes, tables, etc.) in order to find a configuration of the object as answer to a given question. The Interactive Graphical Question (IGQ) is a resource similar to the Tutorial, but the code given back does not correspond only to the two options correct or wrong answer. In fact, the answer required by an IGQ differs with respect to the one of the Tutorial for two features. On one hand it is not unique, that is more than one configurations of the graphical objects can be correct. On the other hand it depends on the movement of some parameters, so each configuration can be correct (all parameters are admissible), semi-correct (a subset of the parameters is admissible), wrong (no parameter is admissible). Finally, the Interactive Semi-Open Question (ISQ) allows to construct the answer to a given question by assembling some available words-blocks by means of dragging. The expected answer should be constituted as a main sentence linked to a secondary one, the latter concerning the arguments to support what stated in the main sentence.

The actual implementation of the DIST-M includes the Frame Introduction, consisting of one script, and the Frame of level 1, consisting of two scripts, named Chapter 1 and Chapter 2.

The following figure shows the design of the script Chapter 1 .



At beginning (task 1) each student is expected to choose a role to play in her group, by negotiating it by chatting with the mates. The roles foreseen are four, assuming 4 as best size of a group for the effectiveness of the

collaboration, and they are the following:

- the Captain, who is the leader of the group who takes care of engaging all the mates in the discussions and in the decision processes; she mediates the social literacy;
- the Scientific Official, who is in charge of collecting and summarizing all the mates' answers concerning mathematical questions to be solved during the mission; he/she mediates the mathematical literacy;
- the Technological Official, who supports the mates who are in troubles in using the platform; he/she mediates the digital literacy;
- the Communication Official, who reports and summarize the conversations of the mates when a shared communication/answer is required.

After the roles have been assigned, the group is required to work with an interactive object (see Interactive Graphical Question) whose suitable manipulation gives the answer to a posed question (task 2 part 1). As already described, each configuration of the object corresponds to a code that is given back to the student. According to the code that the student insert in a text box, a personalized reflective question is delivered (task 2 part 2). The aim of such question is to let the student focus on further possible exact configurations of the object, if she was successful; on the reason of her choice, in case of semi-correct configuration; and on what has brought him to generate a wrong configuration, in case of unsuccessful. Such part of the task wants to be steer the student towards self-regulation processes by means of being aware of what done and why.

Then the student is required to answer to an individual open question, aimed to shift from the previous experience to a general case (task 3). It should bring out the elaboration of arguments to justify the given answer. Each student has to post his/answer in a Question and Answer Forum, so that she cannot be influenced by reading first the arguments of the peer and force the participation.

After all the students posted their answers, a discussion starts, using the previous forum, in order to elaborate a shared answer (task 4). The use of the forum guarantees that everyone completes the previous task, otherwise they cannot access to the peers' answers, and differing from the chat where communication is immediate and not so formal, in the forum there is an implicit request of a shift towards a more literate register.

Once agreed the answer to be given as shared one, the students are required to deliver it by using the Moodle task module used collaboratively (task 5) so that each member takes his/her responsibility to deliver a shared answer.

In the next step, the student works individually (task 6) in order to convert the shared answer previously found into a more literate forms assembling suitable words-blocks (see Interactive Semi-Open Question).

According to the argumentative aim, the words-blocks have been constructed in order to highlight the causal structure of the sentences, that is the causal conjunctions (i.e. since, because, etc.) constitute single blocks, whilst the other blocks allow the construction of the two sentences (main and conditional ones) to be linked by the causal conjunctions. The device is able to recognize the correctness of the construction independently on the order of the sentences.

Once finished the previous construction, the student is asked to post it on the group Question and Answer Forum (task 7) with the request of explaining his/her reasoning. If she was successful in the previous task, then

she is acknowledged of this (she has the title of Champion) and he/she is asked to help her mates. All the students are required to discuss the answers in the thread.

The Champions of all groups (eventually, also a teacher who can be essential when there is no champion) are expected to be available in a general forum for anybody is in troubles (task 8).

At the end of the activity, the students are required to edit a Group LogBook (task 9) and an Individual LogBook (task 10). The first one is composed using a Moodle collaborative wiki, aiming at collect and store all the cognitive information useful for the mission. The second one is referred to a metacognitive reflection of the student on the activity, on the difficulties encountered and how he/she overcomes them. The DIST-M has been tested in a pilot involving 10 degree students from High School focusing on humanities "Virgilio" of San Giorgio del Sannio (BN), in the south of Italy. The students involved were 11, divided into 4 groups, 3 of which consisting in 3 members and 1 consisting in 2 ones. In groups of 3 members, one of the students played 2 roles (task 1), whilst in the group of 2 members, each student played 2 roles. Students were divided into groups randomly by the researcher and the members of the same group could communicate only by the tools of the platform. Each student worked on her PC. The researcher supported the students in the initial phase of access to the platform by providing preliminary indications. Each student logged into the platform by username and password provided by the researcher. Students, therefore, appeared anonymously on the platform, that is the username showed on the screen were something like S1, S2, …, and so on.

The aim of our DIST-M is to facilitate the construction of arguments and, therefore, we are interested in the production of written verbal arguments by the student to support the solution of a problem. Some theoretical models of analysis of the arguments do not refer to language but a written argument is, first, a written text. So the student production of a correct text and an acceptable explanation are closely intertwined. This is why we chose to use a linguistic approach to analyse the data, by means of specific tools, such as textual cohesion, which allows to create the texture of a text, making it a single entity rather than a collection of words and disorganized sentences (Halliday and Hasan, 1976).

Looking at the tasks' flow, we can note that the improvement has been mainly fostered by two key points:

- the social tasks, that require to negotiate a delivery shared by all the members of the group, seem to come to light the need of producing arguments to support the answer; this request was present from the beginning, but many students did not give arguments when delivered individually;
- the task 6, guided by the device, that supports the treatment from the sentence in a colloquial register chosen by the group to sentence in a literate register, foster not only to refine the argument, but mainly to deepen the students' understanding as shown by their further cohesive sentences produced to explain their reasoning.

The above outcomes encourage us to go on further investigating the effectiveness of the designed DIST-M for promoting the ability of converting reasoning in constructing arguments expressed by cohesive texts.