Information Society Technologies (IST)

Programme

Project Number: IST4-26751

ReMath
Representing Mathematics with Digital Media

SCENARIO DESIGN, FINAL VERSION

Deliverable Number: D17

Due date of deliverable: 30/11/2008

Actual submission date: 15/12/2008

Start Date of Project: 01.12.2005

Duration: 36 months

Version:

Work Package: WP3

Lead Partner: Istituto Tecnologie Didattiche – CNR

Contributing Partners: Université Joseph Fourier, Université Paris, Università degli Studi di Siena, National & Kapodistrian University of Athens, Talent Anonimos Etaireia Pleroforikis, University of London

Authors: R. Bottino, J. Earp, G. Olimpo, M. Ott, F. Pozzi, M. Tavella

Contact: Giorgio Olimpo:olimpo@itd.cnr.it

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	√
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Project Coordinator:

Research Academic Computer Technology Institute (RACTI)
eLearning Sector
"D. Maritsas" Building, N.Kazantzaki str.,
University Campus, GR 265 00, Rio, PATRAS

Project Coordinator	Administration Manager
Chronis Kynigos	Farmaki Maria
kynigos@cti.gr	farmaki@cti.gr

Partners:

1. Université Paris 7 Denis Diderot, 2 Place Jussieu, 72251, Paris, France,

2. Université Joseph Fourier Grenoble 1, Avenue Centrale 621, Domaine Universitaire, 38041, Grenoble, France

3. Consiglio Nazionale Delle Richerche, Piazzale Aldo Moro 7, 00185, Roma, Italy,

4. Università degli Studi di Siena, Banchi di Sotto 55 , 53100, Siena, Iitaly,

5. National & Kapodistrian University of Athens, Educational Technology Lab, Faculty of Philosophy, Pedagogy and Psychology Secretariat, School of Philosophy (3rd floor), Panepistimioupoli, 157 84 Ilissia, Athens, Greece

6. Talent Anonimos Etaireia Pleroforikis, Plateia Karitsi 4, 10561,

7. Institute of Education, University of London, 20 Bedford Way, WC1HOAL, London, United Kingdom

Table of contents

1. Introduction

The present deliverable contains the description of the work carried out during the last phase of WP3 (from June 2007 to November 2008) .
In particular, while Del. 7 contained the description of the pedagogical scenario concept and Del. 10 described the way such concept was reified by the ReMath partners in a number of pedagogical plans through the use of the PPM (*Pedagogical Plan Manager*), this deliverable focuses on the evaluation of the work done (see Fig. 1).

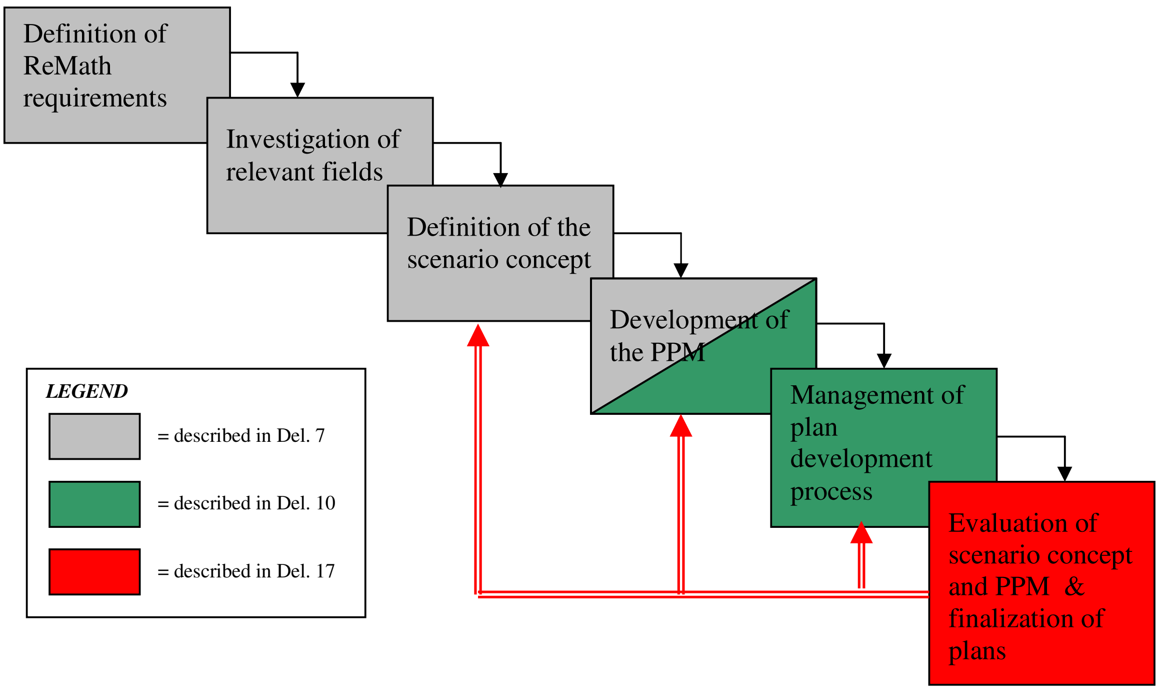


Figure 1: stages of development

In order to have an idea of the appreciation of both the pedagogical scenario concept and PPM by partners and users in general, an evaluation model has been defined, which was already introduced in Del. 10. In the present deliverable we provide a description of the final version of such evaluation model, as it finally emerged from the negotiation within the ReMath consortium, and we report the main results obtained by its application to the existing plans.
Moreover, we (as WP3 leader) will look at the evaluation from our standpoint and carry out a meta-analysis derived from the direct observations of the use done by partners of both the PPM and the scenario concept. This will allow an overall evaluation of the work carried out in WP3 and an in depth reflection on the strong points and weaknesses of the scenario concept and the PPM, with the final aim of possibly identifying guidelines for future work and/or research questions that still remain open.

2. A model for evaluating the "pedagogical scenario" concept

As already introduced in Del. 10, within WP3 an evaluation model has been defined for assessing the concept of "pedagogical scenario" elaborated within the same WP through the project lifespan, with the aim of investigating the users' level of satisfaction and general impressions concerning the pedagogical scenario itself and the way it has been implemented in the PPM.
It is to be noted that the term "pedagogical scenario" is used here in its broadest meaning, that is to say that this evaluation model does not address only the conceptual model elaborated by ITD, but

rather the combination of all the elements produced within WP3, i.e. the scenario concept, the PPM and the existing pedagogical plans (see Fig. 2).
As a consequence, the model is based on the three different perspectives that need to be assumed when considering the "pedagogical scenario" seen in its complexity: the *author's perspective*, the *reader's perspective* and the *experimenter's perspective* (see Fig. 2).

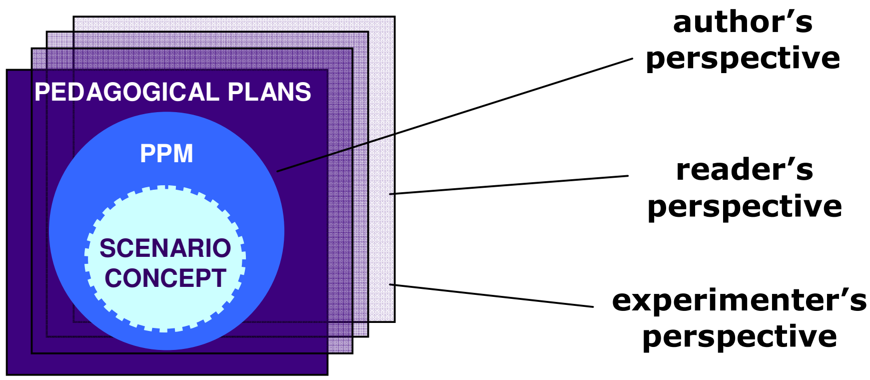


Figure 2: perspectives and elements to be considered in the evaluation of the "pedagogical scenario"

The *author* in ReMath is usually a researcher who uses the PPM Editor for elaborating a plan which, as already mentioned, is based on the DDA his/her team has developed or on an "alien" DDA (that is a DDA developed by another team).
The ReMath *reader* is one (either a teacher or a researcher) who reads the plan through the PPM Viewer either with the aim of better understanding how a DDA can be used in school practice, or with the aim of deciding whether to experiment the plan or not.
Finally, the *experimenter* in ReMath is the one who uses the plan for enacting the activities envisaged in it.
In other words, even if at first glance some overlap may exist between the reader's and the experimenter's perspective, the main difference between the two lies in the fact that, while the reader simply reads the plan without necessarily using it, the experimenter actually uses the plan as a support for enacting the plan itself.
As a consequence of the organization of WPs in ReMath, the consortium agreed that, while the author's and the reader's perspectives are evidently a concern of WP3, the experimenter's perspective falls (at least partially) under WP4 (see Fig.3).

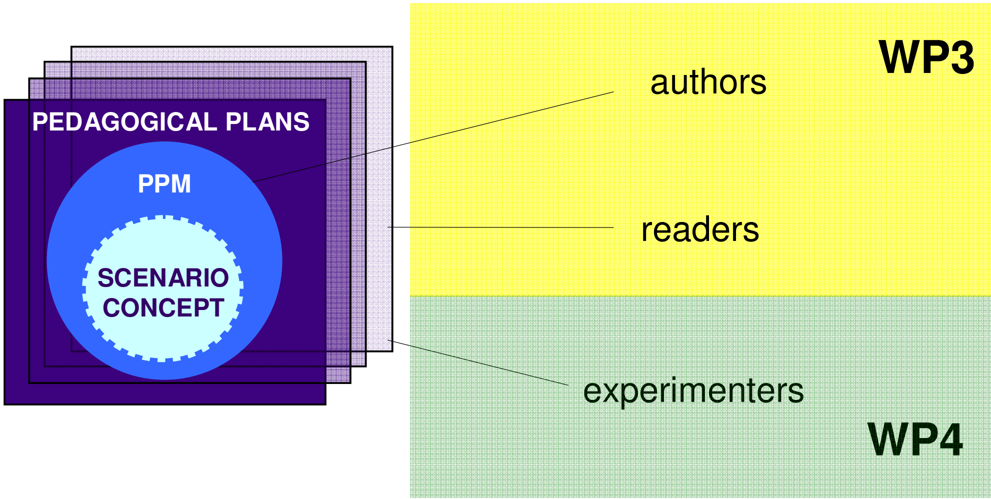


Figure 3: perspectives and WPs

For this reason, while ITD (responsible for WP3) elaborated and gathered data as far as the author's and the reader's perspectives, the Siena team (responsible for WP4) elaborated the means for gathering data on the experimenter's perspective.
In any case, this report syntheses all the results obtained, so to provide a complete picture of the evaluation process.

3. Evaluation method and tools

In order to operationalize the evaluation process, a number of indicators have been identified, that have been organized around two main categories: indicators addressing the ***perceived ease of use*** and those focusing on the ***perceived usefulness***[1] (see Fig. 4).

perceived ease of use	**perceived usefulness**
• tool familiarization	• model/structural aspects
• interface characteristics	• top-down representation
• support (e.g. Help, FAQ)	• pedagogical descriptors
• …	• …

Fig. 4: indicators of the evaluation model

In particular the *perceived ease of use* investigates the effort required by the user (being it the author, the reader, or the experimenter) for using the PPM, in terms for example of interface quality, adequacy of support provided, general understandability of the tool, etc.
The *perceived usefulness* focuses on the possibility offered by the scenario concept and the PPM to enhance the user's performance[2], in terms for example of adequacy of the structure of the model, suitability of the pedagogical descriptors, ability of the model to present the information effectively, etc.

[1] For a definition of "perceived ease of use" and "perceived usefulness", see Del. 10.
[2] The "performance" of course is different for the different users (i.e. the author's performance consists of creating plans, the reader's performance consists of reading and understanding them, the experimenters' performances encompasses their run).

In order to carry out the evaluation, different evaluation means have been developed for gathering the data. In the following, means are briefly described for each perspective.

3.1 Author's perspective – means of evaluation

First of all a questionnaire was developed and given to the authors of the FAMILIAR plans, with the aim of investigating the authoring procedure followed and the author's appreciation of PPM Editor and of the underlying scenario concept. Deliverable 10 contains both the questionnaire and the discussion of the main results obtained.
Afterwards, since the same authors were also in charge of developing ALIEN plans, informal interviews have been carried out, focusing in particular on how they approached alien plan design and on the dynamics of alien plan development. The interviews were based on open questions for narrative responses. In Annex 1, you can find the list of the questions and the notes taken by the interviewer, which were subsequently presented to interviewees for verification/modification/integration.

3.2 Reader's perspective – means of evaluation

While – as already mentioned - the evaluation from the Author's perspective concentrated on the PPM Editor, the object of the Reader's perspective was the PPM Viewer.
Here it is worthwhile saying that, while the former tool was an attempt to meet an explicit need of the project, the latter was conceived largely as a mirror of the authoring environment, able to allow the plan reading. This implied that the tool offers simple viewing capability deemed mostly to the ReMath researchers.
As a consequence, the main aim of this evaluation process was not so much the assessment of the tool itself, but rather the definition of "possible reading requirements" on behalf of a potential "external reader" (i.e. different from the ReMath researcher), dependently on her role (teacher, researcher, etc.). For this reason the evaluation from the Reader's perspective took the form of a "needs analysis" carried out with the support of "neutral readers" through the use of case studies.
In particular, a test group of 3 readers was set up, composed of a maths/science teacher (lower secondary school), a maths teacher (upper secondary school) and a math teacher/researcher. As already mentioned, the choice of having 3 different kinds of readers was dictated by the need to (possibly) cover all the "potential" readers of a plan.
The 3 readers carried out an evaluation into two steps: firstly they were asked to go through an "unguided plan reading" (i.e. they freely chose how to approach reading), and afterwards individual interviews were organized with a focus on one particular plan.
Generally speaking, the evaluation focused on the following aspects:

- general attitude and practice by the interviewees on pedagogical planning
- approach to reading plans in PPM
- PPM viewing capability (not plans themselves)
- pedagogical scenario concept.

In Annex 2, you can find a synthesis of the interviews to the three readers.

3.3 Experimenter's perspective – means of evaluation

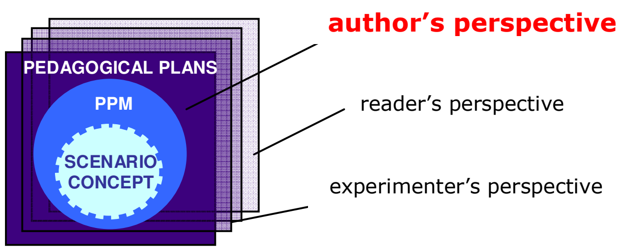
The experimenter's perspective was investigated by the Siena team (WP4) through two questionnaires.
The former questionnaire aims to collect information about experimenting teachers' interactions with the plans at different stages of the experiment. Partners were asked to fill in a questionnaire for each class where plans were enacted.
The latter questionnaire aims to evaluate the ability of the PPM and scenario concept in supporting the experimenting researchers with respect to their research activity.

In Annex 3a you can find the two questionnaires produced by the Siena team, while Annex 3b contains the synthesis of the answers provided by partners.

4. Evaluation results

In the following a synthesis of the main results obtained by the evaluation process is reported.

4.1 Author's perspective – main results



The results obtained by the evaluation of the Authors' perspective (familiar plans) have already been presented in Del. 10 (both synthetic and analytic data). Here a synthesis of the results is reported:

- partners' initial experience using the PPM was largely positive;
- the tool provided a satisfactory level of support for the task of designing familiar pedagogical plans;
- all Authors stated the results obtained with the PPM met their expectations;
- all Authors but one declared that the conceptual model underpinning the PPM helped in expressing the idea they wanted to put into practice;
- the majority of them stated also that their initial ideas were brought into sharper focus by the use of the PPM Editor;
- according to Authors, the key advantage of the PPM is in shaping the plan and working at different levels via the structure manager;
- while no major problems were reported, some Authors did express the impression that constructing their plans involved considerable effort, partly because the scenario concept and descriptor set called on them to fragment their ideas. Analysis of the open-text reactions expressed in response to different questions indicated that this problem mainly concerns the presence of the RATIONALE and THEORETICAL FRAMEWORK fields at different levels of the descriptor schema.

As far as the results obtained by the evaluation of the Authors' perspective focusing on alien plans (for an analytical view on the responses provided by the interviewees, see Annex 1), they mainly convey information about how authors approached alien plan production and on the dynamics of plan development.
In particular, the evaluation brought to light that the starting point for most of the teams to design their alien plans was – as is it reasonable - the analysis of the DDA to be experimented and the study of its functionalities, seen in conjunction with the consideration of the local context and the curricular constraints to be satisfied.

> *"Initially, attention focused on how suitable the DDA was for the given experimental context and on the sort of activities that might be applicable within that context. Once these aspects had been verified, the team then proceeded to gain a more thorough understanding of the DDA, especially its structure and design rationale…."* (ETL)
>
> *"At the start, familiar and alien DDAs were compared…."* (Metah)

> *"The initial starting point was how any learning activity based on the DDA would fit with the local curriculum; this was an institutional constraint as official approval is required before experimentation can take place….."* (IOE/LKL)
>
> *"The alien plan-building process began with (a) exploration of the DDA's most recently-added functions (the team's previous experience had given it familiarity with the tool) and (b) analysis of its suitability in the local context and how it might be adapted in response to the maths curriculum…."* (ITD)
>
> *"….The actual authoring process focused initially on the "didactical functionality" of the DDA, considering: the innovative aspects that the DDA afforded and the links these have with maths meanings and educational goals….."* (Siena)

In some cases, the familiar plan served as a strong source of inspiration:

> *"….The familiar PP provided strong inspiration for the theme of the alien PP activity. A F2F meeting was held with the familiar DDA group to compare activities."* (IOE/LKL)
>
> *"…Initially, activities in the familiar PP were examined. Ideas for possible tasks were discussed with the second alien team…."* (DIDIREM)

Independently on the use of the familiar plans as a source of inspiration on behalf of the alien teams, it is interesting to note that in the narratives there are a number of mentions concerning a certain level of cross-fertilisation between familiar and alien teams.

> *"…Cross-reference was made with the familiar PP both in the PPM and in 2 F2F meetings, which also led to further technological development of the DDA…."* (Metah)
>
> *"…The familiar PP provided strong inspiration for the theme of the alien PP activity. A F2F meeting was held with the familiar DDA group to compare activities….*" (IOE/LKL)
>
> *"…Proposals were made to the familiar team about how the DDA might best be brought to maturity in the light of the alien PP…."* (DIDIREM)

Some feedback concerned the use of the PPM, which was mainly implied for providing a structure to the alien pedagogical plans, as it is illustrated by the following excerpts.
There is only one mention (the last reported in the following table) that the plan was completely conceived outside the PPM.

> *"During elaboration of the alien PP, the PPM was used as a support for defining and shaping the plan structure, and for checking its completeness and congruency; in these respects the PPM proved highly useful. The actual data describing the plan were first recorded in a Word doc and later transferred into the PPM."* (ETL)
>
> *"Drawing on the plan structure suggested by the TF, the authors developed the ID Description, Rationale Description and Theoretical Framework fields "vertically" through the plan from the highest root level right down to the leaves, thus generating a kind of backbone that was laid down before other aspects were fleshed out."* (Siena)
>
> *"Firstly an initial plan structure was built in the PPM that comprised four basic activity phases. The ID and RATIONALE fields (considered to express the essence of the plan) were completed, starting from the root and working through the plan structure following a more or less top-down procedure. Subsequently the learning activities were designed in collaboration with the experienced teacher: this was done outside the PPM and later transferred into the plan. The main authors explained to the teacher the parts of the plan considered pertinent, and the teacher provided input about the more concrete aspects described in SPECIFICATIONS of the activity nodes. This combined top-down and bottom-up input led to zig-zag development and refinement of the plan as a whole. Neither of the two teachers had*

direct access to the English-language plan in the PPM but were provided with Italian-language guides for enacting the learning activities proposed in the experimentation." (Siena)

"The outcome of the process was a draft plan described in a Word file (language constraints prevented use of the PPM). This draft plan was then transposed into a PP in the PPM, retaining the simple structure outlined in the file (one activity only). In the meantime, ongoing modifications to the plan were recorded in the Word file version. The experimentation phases was captured in audio recordings, reports and students' worksheets." (ITD)

Besides these kind of information, the interviews provided also useful indications regarding the involvement of the experimenting teachers in the design of the alien plans. Even if the degree of their involvement was different in the various teams, generally speaking it seems that the teachers acted more as "supporting actors" during the design process, by taking part to brainstorming, providing feedback, swapping ideas, etc.

"…In parallel, PP design ideas were brainstormed and developed with the experimenting teachers, who did not view the existing alien germ." (Metah)

"… The alien PP was developed as a collaborative effort with teachers. …. Teachers' input for PP activity design was made on paper." (IOE/LKL)

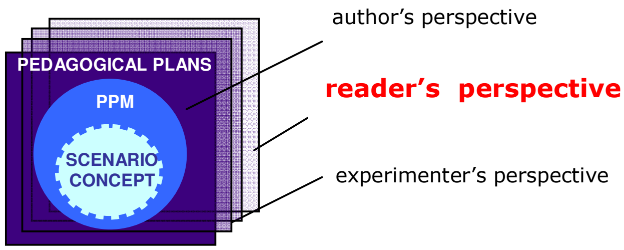
"A meeting was held with the teacher-experimenter group (the same one that had worked on the research team's familiar plan) in order to swap ideas." (DIDIREM)

"This initial analysis was conducted jointly by the project team with teachers involved in the experimentation." (ITD)

"The teachers were given access to the plan in the PPM and a printout, but there is no indication whether these were actually consulted. A F2F meeting was held to illustrate the key ideas of the plan (objectives, activities, core of the TF) and to present the DDA. The teachers did not contribute to plan authoring, but did provide some ideas". (Siena)

These information concerning the role of teachers in plan development have been afterwards confirmed by the results obtained within the evaluation from the Experimenter's perspective (see below).

4.2 Reader's perspective – main results



The synthesis of the interview transcripts taken during the Reader's evaluation process are contained in Annex 2. In the following we discuss the main points emerged by the interactions with the three "exemplar readers".

Generally speaking, as far as the general attitude and practice towards pedagogical planning, the three readers attributed high value to planning and to sharing/reusing planning artifacts and

recognized as important both contingency factors and their impact on the design and enactment of a learning activity.
The reading procedures was mainly sequential at the beginning, then systematic. The fields that attracted more the attention of our readers were: IDENTITY → Description, SPECIFICATIONS, TOOL.
After having navigated the PPM and explored in detail the plans through the PPM Viewer, our readers were able to highlight a number of strengths and weaknesses of the tool, which are reported in the following.
All in all our readers were satisfied with the PPM and found that the hierarchical organization was a good way of representing plans.
Despite this, they also pointed out the difficulties they had in using the PPM Viewer in their role of teachers. In particular, they claimed in a way or in the other, a sense of overload of information and some kind of redundancy of contents.
In particular, according to the math upper secondary teacher, the presence of the theoretical data, is of little use for reuse purposes.

> *"…There a lot of interesting ideas on both sides - theory and practice, but I found them mixed up along all each plan, so that I was not able (probably my fault) to collect and assemble all the key elements which are necessary to put in practice each plan."*

In particular, this teacher claimed the fact that most of the contents required scrolling the page and this did not facilitate comprehension; from this perspective – he suggests - length limit of data fields would have helped.
Besides, he got confused "with the correspondence from the Structure Manager (left of the screen) and the content window aside" and this was mainly due, according to him, to the fact that HIPPs and SNIPPs were not visually distinct and the passage from one to the other was not immediately clear.
His suggestions to improve the overall readability of plans concerned the extrapolation of the activities, that could be facilitated by summary of activity ideas and the activation of options to hide title bars and inheritance.
Very similar impressions were also captured by the teacher / researcher, who claimed that redundancy "makes it difficult to find out what is the practical plan to be put in practice".
Besides, as far as the relationship between the structure and the contents of the plan, he stated:

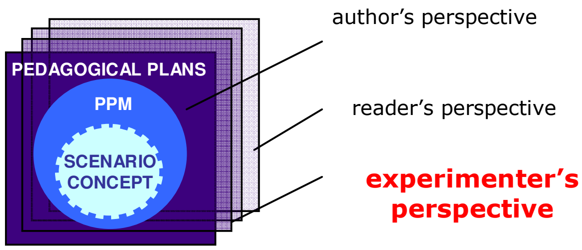
> *"It is vital to allow the reader to have clear at any moment what part of the structure he/she is reading. The content does not reflect the structure as it is represented in the model on the left, which unfortunately is not visible when page is scrolled down. One possibility could be to make the Structure Manager floating, and to mark areas of the content with same colours of the structure as represented in the left model. In this way at least the dept of pieces of content would be visible at any moment"*

Besides the "floating Structure Manager" (i.e. a Structure Manager that comes down as you scroll down the page), he suggested inherited text to be hidden and indicated via a button or an icon.
Even the third reader (maths lower secondary school) claimed that redundancies, empty fields, inheritance and title bars were difficult to use and some time distracting. Besides, despite acknowledging the Structure Manager to be an "excellent form of representation and navigation", he suggested to improve it by making it floating.

All the indications / suggestions obtained by our readers suggest a basic requirement for the PPM Viewer, that is the need to have a simplified interface, with less, more practical information, so that a potential adopter of a plan is able to get an immediate, complete picture of the plan. In other terms, from the evaluation it emerges that, while the structural information seem to be adequately conveyed by the PPM Viewer, the contents of plans need to be filtered, so to allow the reader to

immediately find out the practical information. On the other hand, it also emerges that theoretical information are useful for some readers and this may indicate the need for two (or maybe more) interfaces able to address different reading requirements (for example teacher, researcher, etc.). This opens the door to further investigations, which may lead to the possibility of having different interfaces according to different users' roles, or - even - the possibility to let the user herself select the information on which to focus on.
The evidence that users have different needs and impressions according to their roles, emerged also from the analysis of the Experimenter's perspective, as it is illustrated in the following.

4.3 Experimenter's perspective – main results



As already mentioned, the experimenter in ReMath was embodied in the various teams by either teachers, or researchers, or both of them.
In the following the results obtained by the investigation of the experimenter's perspective are reported (see Annex 3 for details).

As far as the results of the questionnaires to the 13 experimenting teachers, it came out that during the design of the pedagogical plans only 7 teachers actively collaborated to the initial design of the plan (in terms of providing ideas, suggesting tasks, defining order of the activities), but in most cases this was only a partial contribution and 2 out of the 7 teachers acted as designers mainly because they were members of the ReMath project. The remaining 6 experimenting teachers did not contribute to the design of the pedagogical plans at all.
Nonetheless, among the above mentioned 7 teachers who participated more actively to the design phase, only 3 collaborated to the actual construction of the plans (2 of which were the team members cited above) and this suggests the idea that during the ReMath project teachers typically did not enter directly in contact with the PPM Editor.
This datum concerning the involvement of the experimenting teachers in the design of the pedagogical plans, is also reflected by the datum concerning how teachers were proposed the activities they were supposed to enact in classroom: 5 teachers never accessed the PPM Viewer and accessed the description of the activities in the form of individual tasks provided via email, or during face-to-face meetings (the researcher explained the functioning and features of the DDA and presented the planned educational objectives, overall structure, kind of activities, schedule and so on of the teaching sequence, as well as the underpinning rationales,… those aspects were discussed with the teachers but no significant variation was made), or even under the form of a tables summarizing the different units of the teaching sequence (educational aims, duration, setting, learning environment and activities proposed to students).
Only 4 teachers read the plans mainly trough the PPM (but not exclusively) and this always happened with the researcher/author's mediation. Finally, the remaining 3 teachers had direct access to the PPM since they were the ones who were even involved in the design phase.
All these data confirm that experimenting teachers in ReMath never acted as the main users of the PPM, but had a sporadic access to the system.

On the contrary, it seems that the PPM constituted an important tool for the experimenting researchers, who used and appreciated it. In particular, most of the experimenting researchers declared the scenario concept helped them in making it explicit / focusing / outlining the theoretical framework, the research objectives and /or the educational hypotheses. Only 1 researcher claimed that the PPM did not help her. Nonetheless, she declared the PPM to be an important tool to communicate to others researchers and a mediation instrument, able to make explicit to others the ideas underlying a plan.

All in all, the scenario concept in ReMath was not so much a way to communicate with teachers, but it was a useful tool to communicate to others researchers; in particular it was used by the ReMath partners both to present the designed activities according to a structural model that was considered methodologically well founded (familiar plans), and to access ideas underpinning the plans realized by others (alien plans).

5. Meta-analysis of use of PPM and scenario concept

As already mentioned, starting from the results obtained by the application of the evaluation model, we (as WP3 leader) have also carried out a direct observation and a consequent meta-analysis of the way the ReMATH partners have used the pedagogical scenario concept and the PPM. In the following the main results of such observation are described.

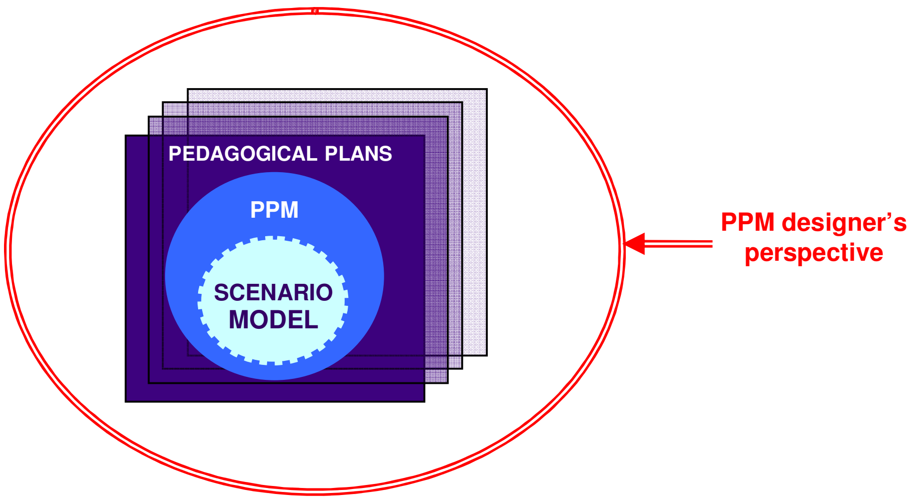


Figure 5: relationship between the evaluation model and the meta-analysis of use

The pedagogical scenario concept and the PPM have been used within ReMath to build 13 different pedagogical plans (6 familiar and 7 alien plans – for further details, see Deliverables 7 and 10). Since the project was evolutionary in nature, there were subsequent versions of the plans; at the moment a total of forty-five plans is available and accessible from the PPM (http://remath.itd.cnr.it).

5.1 Analysis of plan development process

As already mentioned, plans have been refined through time in different steps: 4 versions of familiar plans and 3 versions of alien plans have been built.
Changes took into consideration from time to time the interactions with the other research groups, the experiences with teachers and students, the reviewers' comments, etc. A first analysis of the way partners have developed the former versions of plans, have already been conducted and the main results are reported in Deliverable 10. In this section, we mainly consider the process that led to the development of the final version of plans (version 4.0) (see Annex 4 for details).

Observing the plans and considering their evolution in time, it turns out that authors have quickly recognized the value of the hierarchical organization as a meaningful and synthetic way of representing a pedagogical plan. Moreover, plans have been spontaneously adopted by authors as an instrument for communicating the general aspects of their plans both internally and externally to the project. As already mentioned in Del. 10, all the structures but one were meaningful since the very beginning and many of them have undergone a process of improvement from the standpoint of homogeneity, consistency and expressive power.

The sources that mainly affected version 4.0 of plans are: feedback by reviewers, results of experimentations, direct contact with contexts different from one's own and direct contact with teachers. Despite this, the changes done in this last phase are not structural, but pertains primarily the descriptor contents.

In particular, during the last Review, the ReMath reviewers claimed that there were inconsistencies in the way some descriptors, such as "Goals" and "Context", were used by partners. For this reason, during the last phase of plan development, partners dedicated a certain effort to rephrase /specify /better explain these fields. As far as Goals are concerned, it is worthwhile mentioning that some partners stated that, in their view, there was no need of stating curricular goals in their plans, because these were not meant to address specific area of the curriculum, but rather they were conceived as transversal activities, "open" to meet students' attitudes. As far as the "Context" descriptors are concerned, these have been improved towards homogenization and consistency.

Plans were also affected by the experiments. In particular, the direct contact with teachers and the need to explain them the kind of activities envisaged in the plans, led to changes in the titles of nodes and to further specifications in "What to do and how" and in the "Resources" as well. Some modification was also required in the envisaged "Time".

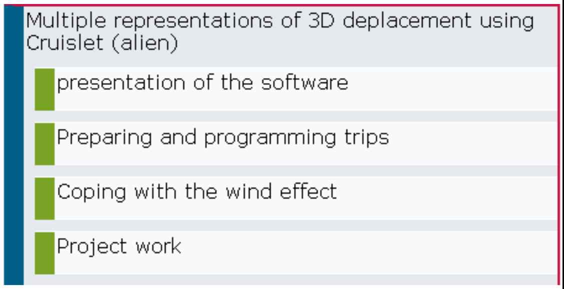
As far as cross-fertilization between alien and familiar plans is concerned, the direct observation of the DDAs running in contexts different from the ones that originated them, was sometimes a source of inspiration for introducing new kinds of learning activities.

5.2 Analysis of plan structures

In order to explore the use of the hierarchical model and capture authors' natural behaviours (possibly identifying the emergence of unforeseen patterns), the WP3 team did not supply plan authors with guidelines explaining how to build the plan structure. Several aspects were left to the authors' interpretation, such as the criteria for guiding the structuring process, together with the identification of new HiPPs and SNiPPs, the level of granularity to be adopted, the choice of the fields to be filled in at each level of the hierarchy and finally the criteria of consistency among different levels of the hierarchy.

When looking at plans in their last version (4.0) and analysing their structures and level of complexity (both in term of length and number of levels), one may note that hierarchies have been used in different ways, varying from one-level hierarchies, to a maximum of four-level hierarchies (see *Figure 6*).

Structure of the plan
"Multiple representations of 3D deplacement using Cruislet"



Structure of the plan
"Functional approach to equations and inequities using ALNUSET"

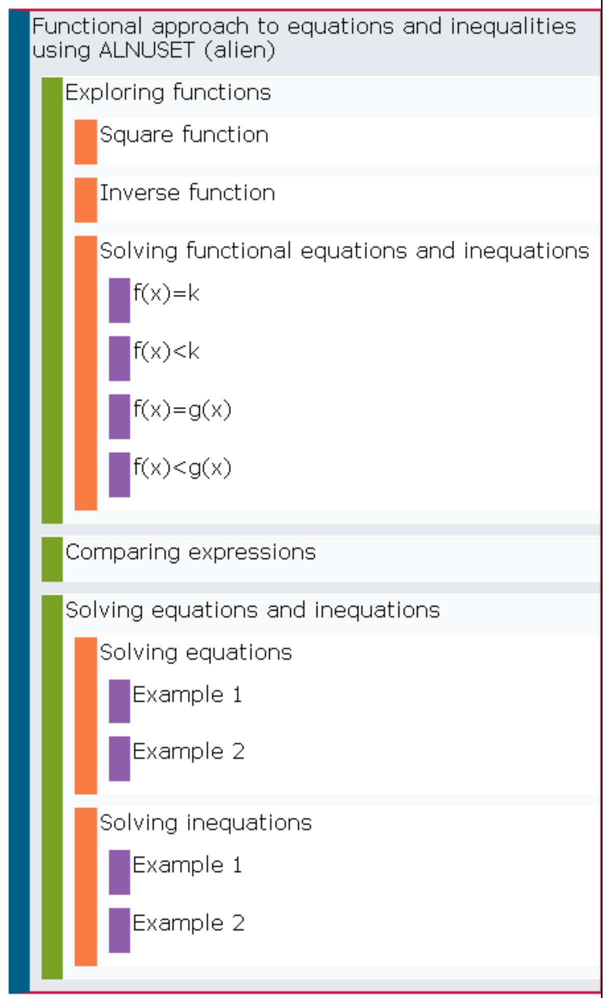
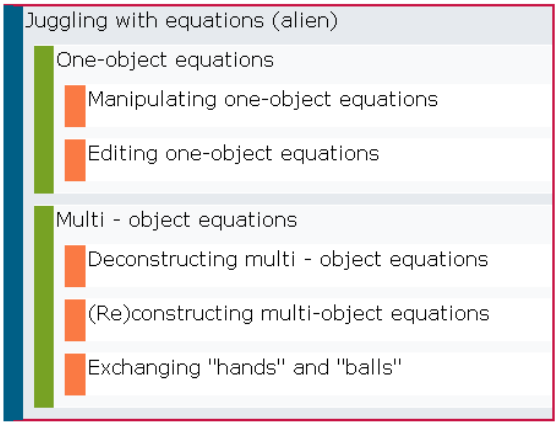


Figure 6 - Examples of implemented structures (comparing the number of levels)

Even the length of structures may vary considerably (see *Figure 7*), depending on both the author's attitude towards structuring, and the activity duration.

Structure of the plan “Juggling with equations”



Structure of the plan “Introduction to algebra: a structural sense of expressions”

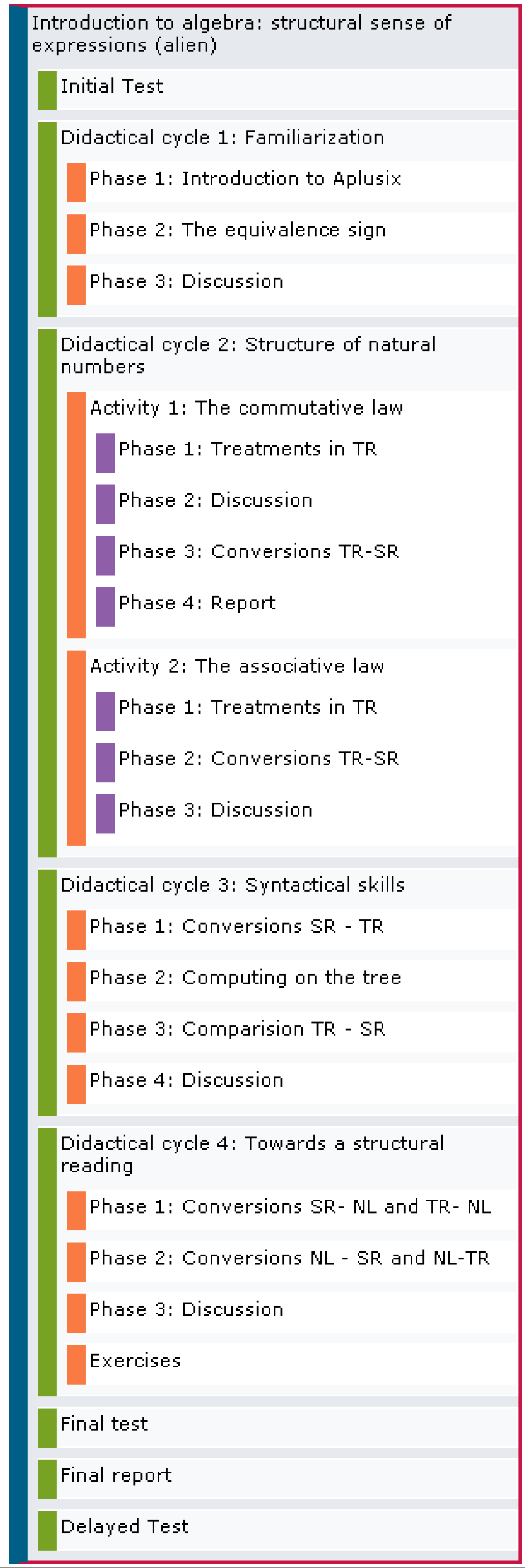


Figure 7 - Examples of implemented hierarchies (differences in length)

Moreover, by looking at plans, it is possible to investigate the criteria used by partners for structuring their hierarchies. The existing plans show 2 main tendencies:

a. *Content-oriented structures*
SNIPPs and HiPPs are often structured after their contents and /or learning outcomes (e.g. “Equality and equivalent notions in treating algebraic expressions and equations”, “Algebraic and polynomial expressions”). This is one of the most common choices, even though frequently this is not a *global* choice, e.g. in many cases within the same HiPP only some of the SNiPPs are content-oriented, while the others follow other criteria (see below).

b. *Structures as pedagogical patterns*
In several cases plans are structured according to the didactic/ pedagogical functions of nodes; examples of this are: “Pre-test”, “Assessment”, “Familiarization”, “Planning”, “Discussion”, “Collaborative challenge”, etc. This is a frequent choice, but it is always a partial choice, being in most cases blended with content-oriented structures (see above).

Though all choices were meaningful and justified, it was manifest that choices of type *a.* favour an easy understanding of what a plan is about, and maybe foster the partial *reuse* of the plan itself. This gradually became clear to some of the authors, whose hierarchies followed an evolutionary path in the direction of an extensive application of criterion *a.* It is worth mentioning that the above mentioned superiority of choices of type *a.* is not an absolute statement. In other contexts, the focus could be, for instance, on pedagogical patterns (requirement to stick to one pattern, authoring based on libraries of patterns…) and this case would obviously imply choices of a type *b.*

Beside an observation of the implemented structures, a semantic analysis is also possible of the words used in titling the plan nodes. In particular, 2 tendencies can be identified as for the kind of titles chosen:

A. *Titles as narratives*
This choice occurs in plans where learning is based on “simulated situations”. In these cases, the plan names refer to events or tasks within a particular situation. Examples of names of this type are: “Avoid the spy”, “The instrument are broken”, “Throwing the ball”, etc. The choice of using this kind of titles always occurs at the lower levels of the hierarchies.

B. *“Plain” titles*
This category refers to those nodes, whose titles convey no didactic/pedagogical information. Examples of names of this kind are: “Introduction”, “Didactical cycle 1”, “Didactical cycle 2”, etc. Within ReMath there was a moderate use of this category and only one plan was completely based on this kind of structure.

It is to be noted that in most cases structures *a.* are associated with titles of kind *A.*, while structures *b.* are often associated with titles *B.*

5.3 Analysis of plan contents

As far as the way authors used the proposed descriptors for expressing the plan contents, an observation has been carried out, aimed at finding out what descriptors have been mostly used and at which level of the hierarchy. Such analysis had the final aim of both finding out possible patterns of behavior in the authoring process and investigating the suitability of the scenario concept to express the authors’ concepts and ideas.
Observations have been carried out by three observers, who, after having agreed on a set of common research questions, worked separately. This implied that each observer was free to adopt a method of analysis of her own, ranging from looking through the single plans, to analyze plans across fields, or even level per level. In the following the results of their observations are reported.

5.3.1 Use of IDENTITY Descriptors

Looking at the IDENTITY descriptors, we can observe that the ***Subject Domain***, as well as the ***Topics*** and the ***Keywords***, have been extensively used, mainly at the root level and then either inherited or specified at the lower levels of the hierarchies.
Usually the field ***Description*** has been adequately used for providing a general overview of the SNiPP / HiPP. It is to be noted, that at the higher levels of the hierarchies (root level and/ or intermediate levels) such description is very often used to present /introduce the structure of the plan.

5.3.2 Use of RATIONALE Descriptors

The field **RATIONALE→** ***Description*** was meant to describe the significant innovative aspects of the proposed SNiPP / HiPP, while the ***Theoretical framework*** should illustrate (or link to) the learning/didactical theory underpinning the SNiPP / HiPP.
Looking at the way authors have used these fields, it is not easy to find out an emergent behaviour: some have filled in these fields at the root level and then inherited them; some have preferred leaving them empty at the lower levels; some others have instantiated them at all levels, etc. Nonetheless, a frequent behavior exists, concerning the focus of the information provided in these fields. In particular, at the root level of the hierarchy it is common to find Rationale and Theoretical framework underpinning both the DDA and the plan. This is mainly due to the fact that in ReMath the pedagogical plans were conceived as means to experiment the DDAs and this imply that very often the information provided are more oriented to explaining the reasons behind the tools, instead of focusing uniquely (or mainly) on the plans and the didactical activities proposed.
Despite the fact that authors have been previously advised of this tendency (see Deliverable 10) and have been asked to avoid it, possibly with the use of hypertext links to external documentation for providing detailed explanations of the Rationale and the Theoretical framework, this inconsistency still persist.

5.3.3 Use of TARGET Descriptors

Generally speaking, the TARGET descriptors are usually filled in at the root level and then inherited at the lower levels.
In particular, the **RATIONALE→** ***Description*** and the ***Theoretical framework*** are hardly used within the TARGET, and in any case, they are typically filled in at the root level and not at the lower levels.
As far as the **POPULATION →** ***Teacher prerequisites***, this field has been usually filled in, primarily at the root level and then inherited. There are only two exceptions of authors who enunciate specific prerequisites at the bottom levels, which are a sub-set of those already cited at the root level.
As to the field **POPULATION →** ***Student prerequisites*** this is usually filled in, but with very different criteria. In particular, in some cases student prerequisites of the root level are the exact sum of those contained at the lower levels; in other cases, there are requisites which are cited inside the plan (at intermediate or lowest level) but are not present at the root level; in some other cases, requisites are expressed at the root level and then integrally inherited. Despite these differences in the use, student prerequisites are usually correctly meant as the description of what students need to know / to be able to do, to run the plan.
The **CONTEXT**, which was aimed at describing the (physical, institutional, socio-cultural) conditions characterizing the environment where the plan is to be run, is usually filled in at the root level and then inherited at the lower levels. Sometimes it overlaps with the field **WORKPLAN→** ***Setting***, where on the opposite authors should describe what the teacher had to arrange in order to run the plan. Despite the fact that this problem had already been acknowledged to authors (see Deliverable 10), such overlap still persists.

Finally, **GOALS** are always filled in at all levels, and are usually correctly declined according to the plan structure.

5.3.4 Use of SPECIFICATIONS Descriptors

As far as the **RATIONALE → *Description*** and ***Theoretical Framework*** within the SPECIFICATIONS, they are usually used at the root level and far less at the lower levels.
Information concerning the **TOOL** are usually provided at the intermediate levels of the hierarchies, whereas the **RESOURCES** are usually generically described at the root level, inherited at the intermediate levels (where they exist), and physically provided at the bottom levels (leaves of the hierarchy).
Finally, as for the **WORKPLAN**, this contains the practical information of the plan and consequently it is usually enunciated at a very general level on the root and then specified at the lower levels. In particular, the ***Setting*** is usually introduces at the highest level and then inherited at the intermediate levels (where they exist). The field ***What to do and How*** at the intermediate levels contains information that are partially inherited from the root level and partially original, in the latter case being devoted to provide a synthesis of the lower levels. This field is usually filled in in all its details at the bottom levels.
As far as the ***Actors' role*** field, researchers, teachers and students are usually mentioned as main actors of plans. Nonetheless, reading through the plans, differences emerge concerning the actual role of researchers and teachers in the various teams, which varied from observer, to designer, to experimenter.

6. Final remarks and future developments

The variety of approaches and modalities of use emerged by our evaluation confirms the flexibility of the scenario concept, which seems to meet different needs. This is particular important, because in some situations it may be appropriate to convey the overall gist of a plan and thus focus at a general, abstract level. On other occasions, attention may need to be directed towards very concrete aspects, thus calling for consideration of details. Moreover, the hierarchical organization lends itself very naturally to build plans which convey the most appropriate level of generality/detail. Since the hierarchical organization naturally supports a process of *top-down* refinement, it becomes possible for an author to push the refinement until the required degree of detail has been achieved.
It is worthwhile mentioning that this possibility to stop the refinement process before the maximum level of detail is reached (corresponding for instance to the need of conveying only a general idea about a given plan), is not necessarily tantamount to a lack of completeness. Indeed, the principle of abstraction implies that each level of refinement should be complete (i.e. self-consistent and therefore fully understandable) without any references to other more detailed levels.

At the same time, the data obtained by the evaluation process suggest that a slightly different interpretation of the hierarchical representation could (a) simplify the process of authoring without compromising the positive aspects implicit in the top down design process and (b) facilitate the reading process, so to improve the communication aspects of the scenario concept and making it fit also for non specialistic use (e.g. easily usable by teachers).
In fact the present pedagogical scenario concept entails that all the nodes in the hierarchy must exhibit the same structure, the philosophy being that each SNIPP should be complete in itself and, at its own level of detail, readable independently on the other nodes of the hierarchy. This choice was aimed mainly at making it possible a mechanism of *plan reusability* which could, in principle, be extendable to all the HIPPs and SNIPPs of the hierarchy. This property had to be intended as the possibility to extract any HIPP or SNIPP from a hierarchy and use it, without substantial changes.
The experience gained in ReMath has enlightened that such an intensive use of the concept of reusability risks to involve, on the one hand, a considerable burden on authors, and, on the other hand, to make plans complex to be read and to be understood, at least by certain categories of

readers.
As we have seen in the section devoted to the results obtained from the meta-analysis, within the same hierarchy authors treated very differently the *root*, the *leaves*, and the *intermediate* nodes (i.e. those on the path from the root to a leaf) and left, on the average, many descriptors unassigned at the intermediate levels. As to readers, they also confirmed that they approached plans by reading through the IDENTITY descriptors at the root levels, and then went down to the SPECIFICATIONS of the leaves.
For these reasons, we think the pedagogical scenario concept could be slightly improved, by assuming the concept of *partial reusability* (as opposed to a *complete reusability*), based on the fact that reusability has a certain design cost and should therefore be implemented only for those HIPPs (if any) where this is considered meaningful.
Of course such improvement would require a consequent shape of the PPM. Unfortunately, since the project lifespan doesn't allow to work further on the PPM, but still there is a necessity to make the developed pedagogical plans available to teachers and easy manageable by them, also for assuring a broader diffusion of the project results even outside the project boundaries, this has led the consortium to agree on the production of new, "teacher-oriented" versions of the pedagogical plans, which are "lighter" to be read and also translated into different national languages. Since this work is done with dissemination purposes, the consortium agreed on considering this effort as part of WP 6.

7. Annexes

Annex 1: Author's perspective - Interviews for alien plan production process
Annex 2: Reader 's perspective - Synthesis of the interviews to readers
Annex 3a:Experimenter's perspective – Questionnaires
Annex 3b:Experimenter's perspective – Summary of Results
Annex 4: Final versions of plans – Abstracts

ANNEX 1 - AUTHOR'S PERSPECTIVE
INTERVIEWS FOR ALIEN PLAN PRODUCTION PROCESS

In order to investigate the alien plan production process, informal interviews were carried with different members of the ReMath teams involved in the design of alien plans.
During the interviews, the interviewer took some notes, which were subsequently presented to interviewees for verification/modification. Some interviewees integrated the information provided during the interviews, with some additional written notes.

List of posed questions

- What was the starting point (germ) for designing your alien plan?
- Did you make any reference to the other team's familiar plan? If so, to what extent?
- What approach and tools did you adopt for developing your alien plan?
- Was plan development a joint effort involving different members of your team?
- What interaction, if any, took place with the DDA designer team during the development of the alien plan?
- What use, if any, did you make of the PPM?

Notes from the responses:

ETL (DDA to be experimented: MOPIX)	Initially, attention focused on how suitable the DDA was for the given experimental context and on the sort of activities that might be applicable within that context. Once these aspects had been verified, the team then proceeded to gain a more thorough understanding of the DDA, especially its structure and design rationale. Development of the alien PP did not involve any reference to the familiar PP, but did draw on the activity models embedded in the DDA itself. One of these provided the basis for the construction of a half-baked microworld which extended the original model by adding multiple equations drawn from the MOPIX repertoire and also devised from scratch by the alien team. The microworld supported an exploration-de/reconstruction-sharing structure, a theoretical construct that the team had had previous experience with and which here defined the structure of the PP itself. During elaboration of the alien PP, the PPM was used as a support for defining and shaping the plan structure, and for checking its completeness and congruency; in these respects the PPM proved highly useful. The actual data describing the plan were first recorded in a Word doc and later transferred into the PPM.
Metah (DDA to be experimented: Alnuset)	At the start, familiar and alien DDAs were compared. This comparison led the alien team to create a germ alien PP in the PPM. In parallel, PP design ideas were brainstormed and developed with the experimenting teachers, who did not view the existing alien germ. Reference to the Theoretical Framework came further downstream. Cross-reference was made with the familiar PP both in the PPM and in 2 F2F meetings, which also led to further technological development of the DDA.
LKL	The initial starting point was how any learning activity based on the DDA would fit with the

(DDA to be experimented: MALT)	local curriculum; this was an institutional constraint as official approval is required before experimentation can take place. Consequently, a project-based approach was adopted as the most suitable way forward and as the option most likely to gain teacher/institutional consensus. It was decided that the alien plan would need to provide students with a range of different activities to choose from, and only one of these would be based on the alien DDA. The **familiar PP provided strong inspiration** for the theme of the alien PP activity. A F2F meeting was held with the familiar DDA group to compare activities. The alien PP was developed as a collaborative effort with teachers. This involved gaining familiarity with the DDA, and analysing its "affordances" with respect to the different (non-DDA based) activities foreseen within the PP. Teachers' input for PP activity design was made on paper.
Didirem (DDA to be experimented: CRUISLET)	**Interviewee n°. 1** The DDA to be used in the alien PP was not completely ready at the outset of the plan development stage: the installation had not been localised, there were some problems with the interface and some support documentation was missing. Initially, activities in the familiar PP were examined. Ideas for possible tasks were discussed with the second alien team. Proposals were made to the familiar team about how the DDA might best be brought to maturity in the light of the alien PPs. A meeting was held with the teacher-experimenter group (the same one that had worked on the research team's familiar plan) in order to swap ideas. Development of the alien PP generated requests for tweaking the DDA to meet the specific needs. Difficulties were faced in finding an adequate match between the potential offered by the DDA and the demands of the alien curriculum. As a result an alternative PP is under development with the alien DDA. **Interviewee n°. 2** Given the institutional distance of the DDA from the French mathematics curriculum, we decided that instead of teachers imposing it on their students, they should present it as a tool to adopt for creating personal projects. The teaching sequence was thus designed in two phases: familiarization with Cruislet and its potential; and use of the DDA in student defined projects (some possible themes were suggested). Pedagogical Plan Presentation of the software a) Collective presentation of the software using a video-projector. The collective presentation will explore the main characteristics of the DDA: virtual exploration of Greece, location of important historical and touristic places by scrolling the 3D map and zooming in/out, creation of an avatar, and presentation of the different existing modes for moving this avatar (entering a final position in (lat, long, height), a vector displacement in spherical coordinates or a city name), presenting the camera system, and looking for reasonable parameters for it, exploiting the interrelation between representations (for instance for getting the coordinates of a particular place),

	exporting the displacement of an avatar into a Logo procedure. b) Collective programming of a first trip with one escale, for instance a flight from Athens to Samos, with a stop in Mikonos or a circular flight (Athens, Iraklio, Rodes, Athens). Programming should first be done by using absolute positions, then by using deplacements. Fi could be 0 in a first step, then vary to produce a change in altitude. c) Small group work for preparing variations of the initial trip. d) Collective discussion: listing the questions raised this first activity and the solutions found to these if any by the groups. Preparing and programming trips a) Collective discussion: coming back to the questions raised at the first session if necessary. b) Small group work: each group completes at least one travel. c) Collective discussion and synthesis : How to prepare a trip? What data are necessary? How to get these? How to program a trip? What has been learnt about the different commands? d) Small group work on a new problem. Adding a turn around Olympe Mount e) Collective discussion: Comparing the strategies used. How to make a circular trip at a given altitude? What to change to make an helicoidal trip? Or to make a spiral trip at a given altitude? Coping with the wind effect a) Small group work on a new problem. Someone has prepared a flight from Athens to Heraklion. The altitude of cruise is 2000m. Program the flight and its visualisation. Unfortunately the programmer has not taken into account the wind. The wind comes from North-West and its force is 40km/h. The cruise speed of the plane is 200km/h. What is the real trajectory of the plane? b) Collective discussion: identifying the difficulties met and the strategies developed. How to model the wind effect? How to multiply vectors by scalars with Cruislet? c) Small group work on the inverse problem: a pilot has prepared a flight from Athens to Heraklion airport. He has planned that after 45mn of flight he would be above Milos Island. Visualise the flight. He arrives at Milos Island only after 40mn of flight. What is the direction and speed of the wind? How to correct the estimate hour for arrival at Heraklion airport? e) A variant of this problem: a pilot has prepared a flight from Athens to Heraklion airport. He has planned that after 45mn of flight he would be just above the centre of Milos Island At the estimated time, he is above a small island, north east of Milos. How to correct the trajectory? Visualise the flight without and with correction. Project work **Possible themes:** - Programming a trip with given conditions in terms of places to be visited for a travel agency (with or without landing) and its visualisation. The program has to optimize fuel consumption (in order to fit better with the TPE national themes). The program can be more or less sophisticated according to the variables taken into account in the modelling process of the flights. - Simulating plane acrobatics involving one or two avatars. DDA based activities were proposed in the frame of a three hour workshop for students that was free from curricular constraints. And we will enter the new PP built for the 3 hours workshop.
ITD (DDA to be experimented: Aplusix)	The alien plan-building process began with (a) exploration of the DDA's most recently-added functions (the team's previous experience had given it familiarity with the tool) and (b) analysis of its suitability in the local context and how it might be adapted in response to the maths curriculum; in particular, attention was focused on the scope for constructivist-oriented activities using the DDA in question. This initial analysis was conducted jointly by the project team with teachers involved in the experimentation. The outcome of the process was a draft plan described in a Word file (language constraints prevented use of the PPM). This draft plan was then transposed into a PP

	in the PPM, retaining the simple structure outlined in the file (one activity only). In the meantime, ongoing modifications to the plan were recorded in the Word file version. The experimentation phases was captured in audio recordings, reports and students' worksheets.
SIENA (DDA to be experimented: Casyopee)	The author had tested the DDA beta version before commencing work on the alien plan. The theoretical framework underpinning the DDA was considered, by its nature, to be congruent with the pedagogical plan model developed in ReMath, especially in terms of the hierarchical structure envisaged for plans. Moreover, the specific TF at hand proved to be influential in shaping plan structure and determining the type of activities that would be proposed. The actual authoring process focused initially on the "didactical functionality" of the DDA, considering: the innovative aspects that the DDA afforded and the links these have with maths meanings and educational goals. The basic outline of the plan (general structure, theme and order of learning activities) was developed separately, and later reworked inside the PPM. Drawing on the plan structure suggested by the TF, the authors developed the **ID Description**, **Rationale Description** and **Theoretical Framework** fields "vertically" through the plan from the highest root level right down to the leaves, thus generating a kind of backbone that was laid down before other aspects were fleshed out. The teachers were given access to the plan in the PPM and a printout, but there is no indication whether these were actually consulted. A F2F meeting was held to illustrate the key ideas of the plan (objectives, activities, core of the TF) and to present the DDA. The teachers did not contribute to plan authoring, but did provide some ideas; the authors felt that enacting the concepts expressed in the TF would be an arduous task. Experimentation began before the alien pedagogical plan was finalised. While no provision was made *in itinere* for iterative modification, the outcome of the enacted activities may well lead to changes in the plan, which in any case requires terminological alterations to reflect interface changes introduced in the latest version of the DDA. One possibility being examined for further development of the current plan version is to try introducing an alternative activity sequence. Although there is currently no specific function in the PPM to support this, it is felt that exploring the scope for such representation could provide useful indications for future development.
SIENA (DDA to be experimented: Aplusix)	The authors had already worked with the DDA in previous experimentations over several years and were thus very familiar with it. So they initially focused on the affordances offered by the new functions of the tool, and specifically on what educational goals these functions could usefully address. Two experiments were to be performed with the alien plan in different classes located in different settings: one was to be conducted in conjunction with an experienced teacher who had already carried out previous classroom experimentation with the DDA, and another with a younger teacher who was new to the tool. Firstly an initial plan structure was built in the PPM that comprised four basic activity phases. The ID and RATIONALE fields (considered to express the essence of the plan) were

	completed, starting from the root and working through the plan structure following a more or less top-down procedure. Subsequently the learning activities were designed in collaboration with the experienced teacher: this was done outside the PPM and later transferred into the plan. The main authors explained to the teacher the parts of the plan considered pertinent, and the teacher provided input about the more concrete aspects described in SPECIFICATIONS of the activity nodes. This combined top-down and bottom-up input led to zig-zag development and refinement of the plan as a whole. Neither of the two teachers had direct access to the English-language plan in the PPM but were provided with Italian-language guides for enacting the learning activities proposed in the experimentation. The authors decided at the outset that the two activities in the second half of the plan should initially be left in an incomplete state and only be finalised once confirmation about the new tool affordances emerged from experimentation of the first two activities. So to a certain degree the plan was designed *in itinere*, i.e. while experimentation was underway, and incorporated some iterative adjustment.

ANNEX 2 – READER'S PERSPECTIVE
SYNTHESIS OF THE INTERVIEWS TO READERS

	S. (upper secondary teachers)	F. (lower secondary teacher)	M. (researcher)
In your teaching practice, what use do you make of plans, designs, etc? Do you ever produce them? Adapt them? Share them?	2 major projects planned per school year. Habitually creates lesson plans for personal use. Designs e-learning courses. No sharing or reuse.	Has only ever used self/group devised template for planning teaching units. Has never felt the need to seek out others' plans but others have used reused his.	Has produced lesson plans and teaching units. Habitually takes informal notes to prepare teaching activities. The only sharing experience has been in research-related activities, not teaching.
How do you see the role of planning activities and artefacts in teaching practice? What are the main factors that need to be taken into account?	Strong need for teachers to access "material with embedded planning" and for reuse of such objects. Any pedagogical plan representation must clearly communicate the potential for reuse, i.e. some degree of generalisability. Prescriptive planning tends to over-simplify the process by excluding vital contingencies that play a central role in teaching-learning processes.	Planning helps to bring ideas into focus and reflect, but the high level of classroom contingency calls for dynamic readjustment of unit plans (granularity dependence). Planning is a good means for work organisation and for bringing innovation.	Planning is always limited in scope by the need to allow for contingency.

How long did this reading take you? How did the task compare with your previous readings (of the reader-selected plans)? What it more or less demanding? Did you impression of the PPM Viewer change?	Took 2 hours to read plan. Found this instance "easier to read" in comparison with others, possibly because better structured and less encumbered by inheritances (though not sure); this suggests that the quality of plan may affect the reading process.	Took around 2 hours to read plan, an effort comparable for others, although language difficulties required extra effort. Used 2 windows, one for Lingro En/It translation.	Read the plan in 2-3 hours. Found this plan easier to read than others with more details in SPECIFICATIONS Generally, impressions of PPM did not alter much depending on plan.
How did you approach the task of reading this plan? What viewpoint did you assume? What specific procedure did you follow in the PPM Viewer?	Assumed the viewpoint of a Teacher focusing on reuse capabilities Browsed thru' plan SNIPP by SNIPP as had already decided to read whole plan on paper (dislikes lengthy reading on screen) HIPP only adopted to test the function itself. Focused on DESCRIPTION, TARGET & SPECIFICATIONS.	Approached task as a "Reader", not as a Teacher. Global reading of entire plan (paper-like) and then backtracking thru' various HiPPs. Navigation SNIPP by SNIPP using SM Field focus on top level DESCRIPTIONS, then TOOL (seen as the fulcrum of the plan). Went outside plan to find TOOL info (not in this plan). Field title bars not used (or understood). Only understood grey text as inherited thru' trial and error	Focused on DESCRIPTION to gain a sense of plan structure. Grasped meaning from DESCRIPTION, RATIONALE, THEORETICAL FRAMEWORK, TOOL, SPECIFICATIONS. Performed the learning activities to understand the tool and plan better. Field title bars not used.
Can you suggest any changes in the PPM Viewer	Scrolling a page never facilitates comprehension: textual content and its context should be presented and be comprehensible on a	Floating Structure Manager. Title bars difficult to use (open/closed, empty/full?)	Link between structure and content would be cleared with a floating STRUCTURE MANAGER and colour coded field title

interface and functions that would make the reader's task easier and improve understanding?	single page. PPM implements the hierarchical model satisfactorily. Clicking apparently "hypertext" titles in the Structure Manager should produce some effect, otherwise why have the "link"? Include a roll-over (or right click) on these titles with summary. HIPP and SNIPP views should be visually distinct to amplify passage from one to the other and give a sense to concepts Extrapolation of activities/intentions could be facilitated by summary of "key activity ideas" (i.e. workplan). Reading would be easier with: option to hide title bars and inheritance; buttons for automatically selecting focus areas at all levels; field menu (as per authoring). Data fields should have length limit with MORE link; authoring environment should have SHORT/LONG division in fields to encourage synthesis	RATIONALE fields should be linked to TOOL. Titles of empty fields are distracting. Structure Manager an excellent form of representation and navigation. Add roll-overs to Structure Manager titles.	bars. Inherited text would be better hidden and indicated only via icon. Predefined view settings could be useful. Plan author should have some control over read views. If all fields in VIEWER were closed by default, drilling the possibility of drilling through the plan would be more intuitive (unaware of this function).
Given your experience, what general impressions do you have about the PPM Viewer and PPs. What	Theoretical data of little use in light of reuse focus. Workplans too prescriptive: they should be half-fabricates with essential clues for reuse (perceives conceptual conflict between	Reading environment could be difficult to use for enactment due to redundancies, empty fields and inheritances. Hierarchical organisation a good way of organising/representing plans.	Redundancies make Viewer unsuitable for enactment purposes

are their strong/weak points?	prescriptive workplans and the adopted Theoretical framework) Hierarchical structure interesting/promising but not exploited to the full by the PPM.	Drilling down with a field selector, as per editor, would be effective for further reading.	
Did you feel that key plan concepts tended to get lost among the detail?	No, this is an inherent difficulty of the design process	Not particularly	Yes
Did you have difficulty understanding the HIPP and SNIPP concepts?	Support material was useful but the concepts are not rendered well in the PPM itself. (See interface comment)	Initially yes, but grasped them with use.	Did not understand distinction
Do the indications for enacting the plan need to be made more visible? How?	No	See interface suggestions	See interface suggestions Need to pair workplan and resources in a clearly displayed manner.

ANNEX 3a - EXPERIMENTER'S PERSPECTIVE QUESTIONNAIRES

PP experimenting questionnaire: the experimenting teacher

This questionnaire aims at gathering information to clarify the interactions that the **experimenting teachers** had with the PPs during different stages of the Teaching Experiments.

Notes:

1. This questionnaire has to be filled one for each class in which the teaching sequence was implemented or it is still going on.
2. In the questionnaire, "teacher" is referred to the teacher who enacted or is still enacting the Teaching Sequence.
3. In the questionnaire, we purposefully distinguish between "Teaching Sequence" and "Pedagogical Plan". In fact, a PP is an organizing tool that encompasses the description of a teaching sequence, but has peculiar characteristics and goals: it has a specific recursive hierarchical structure, and it puts in focus specific aspects (e.g. rationales)… which could be not explicit in the description of a Teaching Sequence.

Experimenting Team:
Teaching Experiment Title (if you implemented the same teaching sequence in more than one class, please use progressive numbers to distinguish among them): e.g. Modelling in Casyopée 1
DDA:

0. (**General Infos**) Before this experimentation, had the teacher ever collaborated with your team?

a. ☐ Never

b. ☐ Occasionally

c. ☐ Continuously
In this case, how long has this collaboration been lasting?
☐ Since after the beginning of ReMath Project
☐ Since before the beginning of ReMath Project

Comments:

Explain what kind of collaboration:

1. (**Design of the Teaching Sequence**) Did the teacher actively collaborate to the initial design of the teaching sequence (ideas, tasks, order of the activities…)?

□ Yes (in case, which was her/his contribution?)

□ No

Comments:

2. (**Construction of the PP**) Did the teacher actively collaborate to the construction of the PP? (by "construction of the PP" we are NOT referring to the editing process, but to the "real" process of construction which might encompass: to decide the PP hierarchy, to make rationales explicit,…)

□ Yes (in case, which was her/his contribution?)

□ No

Comments:

3. (**Before the Teaching Sequence implementation**) How did the teacher access the plan of the Teaching Sequence?

a. □ (s)he read the PP by her/himself
specify whether (s)he read the PP
□ only through the PP Manager (http://remath.itd.cnr.it)
□ also through the PP Manager, but not exclusively, or
□ without the PP Manager

b. □ (s)he read the PP with the researcher/author's mediation (support, intervention,…)
specify whether (s)he read the PP
□ only through the PP Manager (http://remath.itd.cnr.it)
□ also through the PP Manager, but not exclusively, or
□ without the PP Manager

c. □ (s)he did not read the PP: the researcher presented her/him the Teaching Sequence in different ways. Specify which ones:

d. □ other, specify:

Comments:

4. (**During the Teaching Sequence implementation**) Did the teacher and the researcher interact (through meetings, chat, e-mail…) with respect to the teaching sequence implementation?

□ No

□ Yes. In this case,

Such interactions occurred:

- □ only occasionally,
- □ at crucial moments,
- □ after each session.

Such interactions aimed at:

- □ evaluating the progression of the implementation of the designed teaching sequence,
- □ both evaluating the progression of the implementation of the designed teaching sequence, and discussing possible adjustments,
- □ visioning the collected data,
- □ other, specify:

Comments:

PP experimenting questionnaire: the experimenting researcher

This questionnaire aims to initiate the evaluation of the PSCM and PPM in supporting the **experimenting researchers** with respect to their research activity.

<u>Notes:</u>

4. This questionnaire has to be filled <u>one for each designed teaching experiment.</u>
5. In the questionnaire, we propose to distinguish between "Educational Hypothesis" and "Research Objective/Research Hypothesis". In our view, the former regard Educational aspects such as the kind of activities, tool features, contextual features, educational goals, etc and the possible links among them. The latter refers to the objectives of the Teaching Experiment (which may include the validation of Educational Hypotheses themselves, the refinement of Theoretical Frameworks, the "understanding" of specific learning processes,…).

Experimenting Team:
Teaching Experiment Title:
DDA:

1. (**Theoretical Framework(s)**) The conceptual model underpinning the Pedagogical Plan helped you in:

a. □ Outlining ____________________ (e.g. limits, potentialities, elements …)
(specify)

b. □ Focussing ____________________ (e.g. limits, potentialities, elements …)
(specify)

c. □ Making explicit ____________________ (e.g. limits, potentialities, elements …)
(specify)

d. □ Refining ____________________ (e.g. limits, potentialities, elements…)
(specify)

e. □ Other, specify:

of the Theoretical Framework(s) which inspired the design of your Teaching Experiment.

f. □ Actually, it did not helped me.

Comments:

2. (**Research Objectives/Research Hypotheses**) The conceptual model underpinning the Pedagogical Plan helped you in:

a. Outlining
b. Focussing
c. Making explicit
d. Refining
e. Other, specify:

the Research Objectives motivating your Teaching Experiment or the Research Hypotheses underlying it.

f. Actually, it did not help me.

Comments:

3. (**Educational Hypotheses**) The conceptual model underpinning the Pedagogical Plan helped you in

a. Outlining
b. Focussing
c. Making explicit
e. Refining
e. Other, specify:

the Educational Hypotheses underlying the designed Teaching Sequence.

f. Actually, it did not help me.

Comments:

4. (**TS Communication**) Do you think that the process of construction of your PP modified your way of communicating(discussing) the Teaching Sequence to(with) the teachers? Did it foster your way of communicating? How? (E.g.: did it help you in identifying aspects, ideas to communicate?)

ANNEX 3b - EXPERIMENTER'S PERSPECTIVE
SUMMARY OF RESULTS

PP experimenting questionnaire: the experimenting teacher

This questionnaire aims at gathering information to clarify the interactions that the **experimenting teachers** had with the PPs during different stages of the Teaching Experiments.

Notes:

1. This questionnaire has to be filled one for each class in which the teaching sequence was implemented or it is still going on.
2. In the questionnaire, "teacher" is referred to the teacher who enacted or is still enacting the Teaching Sequence.
3. In the questionnaire, we purposefully distinguish between "Teaching Sequence" and "Pedagogical Plan". In fact, a PP is an organizing tool that encompasses the description of a teaching sequence, but has peculiar characteristics and goals: it has a specific recursive hierarchical structure, and it puts in focus specific aspects (e.g. rationales)… which could be not explicit in the description of a Teaching Sequence.

Experimenting Team:
Teaching Experiment Title (if you implemented the same teaching sequence in more than one class, please use progressive numbers to distinguish among them): e.g. Modelling in Casyopée 1
DDA:

0. (**General Infos**) Before this experimentation, had the teacher ever collaborated with your team?

a. ***4 → Never***

b. ***4 → Occasionally***

c. ***6→ Continuously***

In this case, how long has this collaboration been lasting?
2 → Since <u>after</u> the beginning of ReMath Project
4→ Since <u>before</u> the beginning of ReMath Project

Comments:
//

Explain what kind of collaboration:
//

1. (**Design of the Teaching Sequence**) Did the teacher actively collaborate to the initial design of the teaching sequence (ideas, tasks, order of the activities…)?

7 **→*Yes*** *(in most cases this was a partial contribution; in 2 cases the teacher was "member of the team")*

6 **→*No***

Comments:

//

2. (**Construction of the PP**) Did the teacher actively collaborate to the construction of the PP? (by "construction of the PP" we are NOT referring to the editing process, but to the "real" process of construction which might encompass: to decide the PP hierarchy, to make rationales explicit,…)

3 **→*Yes*** *(2 of which were the same that had been declared "members of the team")*

10 **→*No***

Comments:

//

3. (**Before the Teaching Sequence implementation**) How did the teacher access the plan of the Teaching Sequence?

a. ***0*** **→ *(s)he read the PP by her/himself***

specify whether (s)he read the PP

□ ***only through the PP Manager (http://remath.itd.cnr.it)***

□ ***also through the PP Manager, but not exclusively, or***

□ ***without the PP Manager***

b. ***4*** **→ *(s)he read the PP with the researcher/author's mediation (support, intervention,…)***

specify whether (s)he read the PP

0 →only through the PPM (http://remath.itd.cnr.it)

3 →also through the PPM, but not exclusively, or

1 →without the PPM

c. ***6*** **→*(s)he did not read the PP: the researcher presented her/him the Teaching Sequence as follows:***

- *(1) drafts of individual tasks and sequences of tasks were provided via email*
- *(2) through email and discussed in face-to-face meeting*
- *(1) through meetings (the researcher explained the functioning and features of the DDA and presented the planned educational objectives, overall structure, kind of activities, schedule and so on of the teaching sequence, as well as the underpinning rationales,… those aspects were discussed with the teacher but no significant variation was made)*
- *(2) under the form of a table summarizing the different units of the teaching sequence (educational aims, duration, setting, learning environment and activities proposed to students). Teachers were allowed to propose modifications of the initial PP.*

d. □ other, specify:

1 teacher created the PP collaboratively with the team

2 teachers were "member of the team"

Comments:

//

4. (**During the Teaching Sequence implementation**) Did the teacher and the researcher interact (through meetings, chat, e-mail…) with respect to the teaching sequence implementation?

1 → No
12 → Yes. In this case,

Such interactions occurred:

1 → only occasionally,
6 → at crucial moments,
5 → after each session.

Such interactions aimed at:

2 → evaluating the progression of the implementation of the designed teaching sequence,
9 → both evaluating the progression of the implementation of the designed teaching sequence, and discussing possible adjustments,
1 → visioning the collected data,
0 → other, specify:
//

Comments:
//

PP experimenting questionnaire: the experimenting researcher

This questionnaire aims to initiate the evaluation of the PSCM and PPM in supporting the **experimenting researchers** with respect to their research activity.
Notes:

4. This questionnaire has to be filled one for each designed teaching experiment.
5. In the questionnaire, we propose to distinguish between "Educational Hypothesis" and "Research Objective/Research Hypothesis". In our view, the former regard Educational aspects such as the kind of activities, tool features, contextual features, educational goals, etc and the possible links among them. The latter refers to the objectives of the Teaching Experiment (which may include the validation of Educational Hypotheses themselves, the refinement of Theoretical Frameworks, the "understanding" of specific learning processes,…).

Experimenting Team:
Teaching Experiment Title:
DDA:

1. (**Theoretical Framework(s)**) The conceptual model underpinning the Pedagogical Plan helped you in:

a. ***2*** **→*Outlining*** *the elements of the theoretical framework that are relevant to each aspect of the design of the teaching sequence and the research process.*
b. ***1*** **→*Focussing*** *on how to frame the potentialities of the alien DDA from the theoretical point of view.*
c. ***8*** **→*Making explicit*** …
- *(1) the role of different theoretical frames and theoretical constructs in designing different parts of the PP (including limits, potentialities, complementarities, inconsistencies).*
- *(1) different theoretical constructs used in each phase of the teaching experiment.*
- *(1) the connections between specific elements of the theoretical framework and educational and research hypotheses.*
- *(1) different elements of the TF and the relation among them.*
- *(4) specific elements of the Theoretical Framework(s) which inspired the design of the teaching experiment.*

d. ***0*** **→*Refining***… (e.g. limits, potentialities, elements…)
e. ***1*** **→*Other,*** specify:
By causing us to reflect on the theoretical basis for the idea of formation of connections between different forms of representation, it helped us to ***identify*** *the need to introduce the semiotic/ discursive approach to 'transfer' of Carreira et al.*
f. ***1*** **→*Actually, it did not helped me.***
Nonetheless, the PPM has been for us an important tool to communicate to others researchers our Teaching Experiment. It has mediated the possibility to make explicit to others the ideas underlying our Teaching Experiment.

Comments: //

2. (**Research Objectives/Research Hypotheses**) The conceptual model underpinning the Pedagogical Plan helped you in:

a. ***0* → *Outlining***….

b. ***4* → *Focussing***…

- *(1) on the research objectives of the teaching experiment as part of validating the educational hypotheses themselves, e.g. at the level of theoretical frameworks employed and the contextual aspects of the experiment.*
- *(1) on how to frame the potentialities of the alien DDA from the theoretical point of view (in case of alien DDA).*
- *(2) on the Research Objectives motivating the Teaching Experiment or the Research Hypotheses underlying it.*

c. ***4* → *Making explicit*** *the research objectives motivating the teaching experiment or the research hypotheses underlying it.*

d. ***4* → *Refining***…

- *(1) the research objectives and hypotheses to be consistent with the theoretical framework and the design of the teaching sequence.*
- *(3) the Research Objectives motivating the Teaching Experiment or the Research Hypotheses underlying it.*

e. ***0* → *Other***, specify:

f. ***1* → *Actually, it did not help me.***
Nonetheless, the PPM has been for us an important tool to communicate to others researchers our Teaching Experiment. It has mediated the possibility to make explicit to others the ideas underlying our Teaching Experiment.

Comments:
//

3. (**Educational Hypotheses**) The conceptual model underpinning the Pedagogical Plan helped you in

a. ***0* → *Outlining***…

b. ***2* → *Focussing***…

- *(1) on different goals, either at the educational, epistemological or cognitive level.*
- *(1) on how to frame the potentialities of the alien DDA from the theoretical point of view (in case of alien DDA).*

c. ***6* → *Making explicit***…

- *(1) the educational hypotheses (e.g. kind of activities, tool features, contextual features, educational goals) in all parts of the PP.*
- *(1) the specific rationales of each choice accomplished in the teaching sequence.*
- *(4) the Educational Hypotheses underlying the designed Teaching Sequence.*

e. ***4* → *Refining***…

- *(2) the activities in Teaching Sequence*
- *(1) the content and the sequence of the designed activities*
- *(1) the Educational Hypotheses underlying the designed Teaching Sequence.*

e. ***0*** → ***Other***, specify:

f. ***1*** → ***Actually, it did not help me.***
Nonetheless, the PPM has been for us an important tool to communicate to others researchers our Teaching Experiment. It has mediated the possibility to make explicit to others the ideas underlying our Teaching Experiment.

Comments:
//

4. (**TS Communication**) Do you think that the process of construction of your PP modified your way of communicating(discussing) the Teaching Sequence to(with) the teachers? Did it foster your way of communicating? How? (E.g.: did it help you in identifying aspects, ideas to communicate?)

No, it has not modified our way to communicate with the ***teacher****, but it has been a useful tool to communicate to others* ***researchers*** *the teaching experiment we have designed and to present it according to a structural model that is well founded from a methodological point of view (familiar) and to access to ideas underlying a teaching experiment realized by another group of researcher (alien).*

The experimenting teacher participated in the process of construction of the pedagogical plan. As a result, from the design phase of the pedagogical plan, it had been developed a common communicational ground between the members of the team that facilitated the implementation.

Since experimentation was carried out by two researchers, one of which acting as a teacher, the PPM helped in focusing on specific elements of the plan and communicating and discussing ideas on the teaching sequence they would follow more effectively.

The clarity about our educational and research objectives developed through the process of construction of the PP may have been indirectly helpful in negotiating the aims of the teaching sequence with the college teachers. The teaching during the experiment, however, was undertaken by members of the research team who had themselves been involved in the construction of the PP.

The teaching sequence was conducted jointly by the class teacher and members of the research team. Construction of the PP, by helping us to make the educational hypotheses explicit, supported the clarity of our communication with the class teacher about the teaching sequence and its aims. We were able to highlight the overall purposes of the teaching sequence and the ways in which each lesson contributed.

Such process helped in:
- *identifying the key elements to be communicated to the teacher;*
- *conveying the specific information of each single session, without isolating it from the global teaching experiment.*

I think that my personal way of conceiving and communicating the description of a Teaching Sequence is largely consistent with the general structure of a PP. In that sense the process of PP constructing did not modify my way of communicating. Rather such process helped in identifying some aspects to communicate to the teacher.
Although we did not ask the teachers to read the PP (neither parts of it), we feel that the process of its construction helped us identify the main aspects of each elementary scenario we considered

necessary to communicate to the teachers (educational goals, brief description, duration, tools and resources used). The teachers were given a table presenting the overall structure of the teaching sequence, and all the resources used during this sequence.

ANNEX 4 - FINAL VERSIONS OF PLANS

The final versions of plans (version 4.0) are available at:

http://remath.itd.cnr.it

IN THE PRESENT ANNEX WE ONLY PROVIDE PLAN ABSTRACTS.

ALIEN CRUISLET DIDIREM new version

ALIEN CRUISLET DIDIREM new version

- Presentation of Cruislet
- preparing and visualizing trips
- programming trips and loops

Passwords

Password to view ●●●●●●●● Password to edit

ALIEN CRUISLET DIDIREM new version

Identity

Title

ALIEN CRUISLET DIDIREM new version

Authors

Artigue, Cazes, Le Feuvre, Lagrange, Meyrier, Vandebrouck

Subject domains

Topics

Language

English

Country

France

Keywords

Description

The global plan is to use Cruislet in the frame of a multidisciplinary work, such as TPE in France (TPE is a multidisciplinary project work that students prepare in small groups during the first half of the academic year in grade 11)

The PP which is described here corresponds to a presentation of Cruislet and its potential use for representing 3D displacements.

Three sessions are devoted to a classroom work directed by the teacher. Students learn how to use Cruislet and solve problems proposed by the teacher.

FAMILIAR : VERSION 4: Approaching functions with Casyopee

FAMILIAR : VERSION 4: Approaching functions with Casyopee

- associated function
  - introduction
  - targeted functions
  - different expressions of a function
- functions and geometry: variables and equations
  - Introduction (to divide a triangle in piece of fixed area)
  - Application (to divide a rectangle in piece of fixed area)
- function and geometry: optimization

Passwords			
Password to view	●●●●●●●●	Password to edit	

FAMILIAR : VERSION 4: Approaching functions with Casyopee

Identity

Title

FAMILIAR : VERSION 4: Approaching functions with Casyopee

Authors

DIDIREM TEAM

Subject domains

- Mathematics

Topics

- Functions, Geometry

Language

English

Country

France

Keywords

- associated functions, geometric functions, optimization, parameters, semiotic registers

Description

The plan proposes a succession of tasks exploiting the potential a priori offered by Casyopee for approaching and studying the notion of function, and especially:

- the role played by functions for solving problems arising from geometrical situations,

- the role played by parameters for studying family of functions and accessing generalization.

Specific importance is given to the construction of tasks where students can choose different variables for exploring functional dependencies and to the connection between algebra and geometry. This connection is supported in Casyopee by geometric expressions which allow to express magnitudes in a symbolic language mixing geometry and algebra. Moreover, according to the choices made for the independent variable, the resulting algebraic expression of functional dependence automatically produced by Casyopee can be of very different complexity. The scenario aims at exploiting these didactical functionalities of Casyopee and the different associated feedbacks, coherently with the theory of didactic situations.

The instrumentalisation process is initiated in each phase of the scenario through a collective phase orchestrated by the teacher, which also serves as a devolution phase for the type of task which is considered.

The scenario is built around three main types of tasks :

- finding targetted second grade functions by acting on parameters (five different tasks according to the semiotic forms used for these functions),

- functional modelling of a geometrical situation for solving a problem of relationships between areas,

-functional modelling of a geometrical situation for solving an optimization problem.

Juggling with equations (alien)

Juggling with equations (alien)

- One-object equations
  - Manipulating one-object equations
  - Editing one-object equations
- Multi - object equations
  - Deconstructing multi - object equations
  - (Re)constructing multi-object equations
  - Exchanging "hands" and "balls"

Passwords

Password to view ●●●●●●●● Password to edit

Juggling with equations (alien)

Identity

Title

Juggling with equations (alien)

Authors

ETL team

Subject domains

- Mathematics
- Mechanics
- Physics

Topics

- Equations
- Algebraic formalism
- Modeling
- Equations of motion

Language

English

Country

Greece

Keywords

- Algebraic equations
- Models
- Animation
- Behaviors and properties

Description

MoPiX constitutes a highly visual and highly interactive constructionist learning environment that provides learners and teachers the opportunity to use it as an authoring tool and develop microworlds embedding a variety of knowledge domains - often in combination - such as mathematics, physics and mechanics. It is designed to foster the construction of virtual models consisting of objects whose properties and behaviours are defined and controlled by equations assigned to them. The models can be animated to provide a visual/graphical representation, while the equations ascribed to the objects are fully accessible and available for inspection and modifications.

The "Juggling with Equations" Pedagogical Plan wishes to engage students in the deconstruction, editing and the (re)construction of MoPiX models representing phenomena such as collisions and motions. The manipulation and the construction of MoPiX-compatible equations, so as to control and define the models' behaviour, will engage students in the interpretation and use of the equations' mathematical formalism, while the animation of the models will offer them the chance to connect the mathematical formalism to its visual/graphical representation.

Navigation in Geographical Space (familiar)

Navigation in Geographical Space (familiar)

- Function as covariation in Geographical Space
  - Learning to fly (Familiarization)
  - Airplanes' chase
    - Avoid the spy
    - Create rules for the chase
  - The instruments are broken
- Variables as displacements in Geographical Space

Passwords

Password to view ●●●●●●●● Password to edit

Navigation in Geographical Space (familiar)

Identity

Title

Navigation in Geographical Space (familiar)

Authors

ETL Team

Subject domains

- Mathematics
- Geography

Topics

- Functions
- 3d representations
- Geographical coordinates
- Sperical coordinates

Language

English

Country

Greece

Keywords

- Function
- Geographical coordinates
- Spherical coordinates
- 3d representations

Description

Cruislet environment is a microworld designed to provide learners with the ability to be involved in exploratory activities focusing on the use of vectors navigating in 3d large scale spaces. In the number of tasks that are included in this hierarchical pedagogical plan the experimentation with the Cruislet environment focuses on the study of the development of student's conceptions concerning the mathematically driven navigations in virtual 3-d geographical spaces. The general mathematical issues are those underlying the use of analytic and/or vector-differential geometry, including functions, co-variation and rate of change. These mathematics are integrated with geo-spatial representations and information, providing opportunities for processes of mathematisation of geographical space

Programmable constructions in 3D geometrical space (familiar)

Programmable constructions in 3D geometrical space (familiar)

- Introductory activity
- Angles in 3D space
  - Revolving door simulation
    - Constructing parallelograms in 2d plane
    - Simulating the opening and closing of a door
    - Constructing a revolving door simulation
    - Extension: Simulating the opening-closing pages of a book
  - Spiral staircase simulation
    - Constructing a stair
    - Constructing a spiral staircase simulation
- Basic sterometrical objects
- Properties of geometrical objects

Passwords

Password to view ●●●●●●●● Password to edit

Programmable constructions in 3D geometrical space (familiar)

Identity

Title

Programmable constructions in 3D geometrical space (familiar)

Authors

ETL team

Subject domains

- Geometry

Topics

- 3d geometrical figures
- Spatial orientation / visualisation
- Dynamic manipulation / transformation of 3d objects

Language

English

Country

Greece

Keywords

- turtle geometry
- 3d space
- 3d geometrical figures
- dynamic manipulation / transformation
- 3d simulations

Description

This pedagogic plan engages students in exploring the mathematical structure of 3d geometrical objects in a 3d computational environment. Students will have opportunities to construct 3d geometrical figures and dynamically manipulate, transform and animate 3d objects often encountered in everyday situations (e.g staircases, sliding doors) through Logo commands and variation tools. The tasks are designed to bring in the foreground issues concerning the mathematical nature of 3d geometrical objects and how these may be dynamically manipulated and tranformed in mathematically meaningful ways. This pedagogical plan involves two sub-scenarios aiming to engage pupils in exploring:

(a) moves and angles in 3d space,

(b) constructions and dynamic transformations of 3d geometrical figures.

Building in 3D (alien)

Building in 3D (alien)

- introduction: planning the overall design
- 2D representations of 3D space
  - Distinguishing forms of representation
  - isometric drawings
  - plans and elevations
- constructing and manipulating in 3D
  - developing 3D sense of movement
  - walls and windows
  - roofs
  - doors
- completing and presenting the design

Passwords

Password to view	••••••••	Password to edit	

Building in 3D (alien)

Identity

Title

Building in 3D (alien)

Authors

Jehad Alshwaikh, Candia Morgan, Guinevere Dyker IOE/LKL

Subject domains

- mathematics

Topics

- 3D geometrical figures
- spatial visualisation
- 2D representation of 3D space
- angles and turns in 3D

Language

English

Country

England

Keywords

Description

This pedagogical plan will engage students in designing and constructing a virtual building. The purpose of the building will be specified by the teacher with constraints or suggestions to encourage creative designs. In this case, the building specified is a new sports centre for the school, but other buildings relevant to the students' context and experience could be substituted with little effect on the overall plan.

Students will construct representations of 3D geometrical objects using both traditional forms of representation (building blocks, isometric drawings, plans and elevations) and a 3D computational environment.

Modelling with Equations (familiar)

Modelling with Equations (familiar)

- Familiarisation
  - Introductory Tasks
  - Creating/Editing equations
- Straight line motion
  - Introduction to straight line motion
  - Perpendicular motion
  - Changing direction
  - Bouncing Ball
- Acceleration
  - Using constant acceleration
  - Debugging models
  - Applying a force to change direction

Passwords

Password to view ●●●●●●●● Password to edit

Modelling with Equations (familiar)

Identity

Title

Modelling with Equations (familiar)

Authors

Jehad Alshwaikh, Ken Kahn, Candia Morgan, Dusanka Nicolic, Niall Winters. Institute of Education - London Knowledge Lab

Subject domains

- Mathematics
- Mechanics
- Physics

Topics

- equations
- kinematics
- dynamics
- graphs

Language

English

Country

United Kingdom

Keywords

Description

This pedagogic plan will engage students in using an innovative interactive learning environment, MoPiX, in which it is possible to construct animated models defined and controlled by equations. Through this activity students will have opportunities to develop their understanding of equations and of how motion may be described and defined. Collaborative problem solving is encouraged both by face-to-face group work and through electronic communication. Students may make use of ready-made models from a web-based repository/library and may also contribute their own models to this library to be used by others.

The plan is structured in three parts:

(i) introductory familiarisation with the use of MoPiX

(ii) straight line motion

(iii) motion with acceleration

Exploring the structure of numerical expressions (alien)

- Exploring the structure of numerical expressions (alien)
  - Initial test
  - Exploring the structure of expressions comparing different representations
    - Introduction to the tree construction in Aplusix
    - Exploring the structure of expressions comparing linear representations and tree representations
    - Solving arithmetic task expressed in natural language using tree representations and linear representations
  - Final test

Passwords

Password to view	●●●●●●●●	Password to edit	

Exploring the structure of numerical expressions (alien)

Identity

Title

Exploring the structure of numerical expressions (alien)

Authors

Chiappini G., Pedemonte B., Robotti E., Viglienzone P.

Subject domains

- Arithmetic

Topics

- Numerical expressions
- Tree representation

Language

English

Country

Italy

Keywords

- Numerical expression
- Tree representation
- Linear representation
- Aplusix

Description

This pedagogical plan concerns an approach to the numerical expressions through an introduction of a new representation system: a tree representation. It makes use of the Aplusix software, which allows to represent expressions either in linear expression or as a tree.

This plan presents an approach to numerical expressions based on an exploration of the structure of numerical expressions. The main aim of the plan is to understand the structure of numerical expressions and the rules that etablish the hierarchical priority of its signs.

Equality and equivalent notions in treating algebraic expressions and equations (familiar)

Equality and equivalent notions in treating algebraic expressions and equations (familiar)

- Initial test
- Algebraic and polynomial expressions
  - Exploring what an expression denotes through an algebra of quantities
  - Exploring equivalent expressions integrating an algebra of operations with an algebra of quantities
  - Exploring opposite and reciprocal expressions
  - Exploring roots of polynomials
- Equations
  - Exploring equations as conditioned equality between two expressions
  - Exploring particular kinds of equations

Passwords

Password to view ●●●●●●●● Password to edit

Equality and equivalent notions in treating algebraic expressions and equations (familiar)

Identity

Title

Equality and equivalent notions in treating algebraic expressions and equations (familiar)

Authors

G. P. Chiappini, B. Pedemonte, E. Robotti, F. Vannucci

Subject domains

- Algebra

Topics

- Algebraic expressions
- Polynomials
- Equations

Language

English

Country

Italy

Keywords

- Algebraic Line
- Algebraic Manipulator
- Activity theory
- Algebra of quantities
- Algebra of operations
- Algebraic expressions
- Polynomials
- Equations
- Alnuset

Description

This pedagogical plan describes an innovative approach for introducing students to the notions of equivalence and equality when they deal with algebraic and polynomial expressions and equations.
It is based on the use of a digital artefact called ALNUSET. In particular, two components of ALNUSET are used: the algebraic line component and the algebraic manipulator component.
The plan is conceptually divided into two modules.
The first focuses on the construction of the notion of equivalent algebraic expressions and on the notion of the root of a polynomial expression.
The second deals with the construction of meaning for the solution of equations considered as conditioned equality determined by the insertion of the equality sign between two algebraic expressions.

Functional approach to equations and inequalities using ALNUSET (alien)

Functional approach to equations and inequalities using ALNUSET (alien)

- Exploring functions
  - Square function
  - Inverse function
  - Solving functional equations and inequations
    - f(x)=k
    - f(x)<k
    - f(x)=g(x)
    - f(x)<g(x)
- Comparing expressions
- Solving equations and inequations
  - Solving equations
    - Example 1
    - Example 2
  - Solving inequations
    - Example 1
    - Example 2

Passwords

Password to view	●●●●●●●●	Password to edit	

Functional approach to equations and inequalities using ALNUSET (alien)

Identity

Title

Functional approach to equations and inequalities using ALNUSET (alien)

Authors

Jana Trgalova, Hamid Chaachoua, MeTAH-LIG, Grenoble, France

Subject domains

- mathematics

Topics

- algebra and functions

Language

English

Country

France

Keywords

- function: x-value, function-value, variation
- equation: solution, solving
- inequation: solution, solving

Description

The main topic addressed in this scenario is “equations and inequations”. Since these notions are not new for the Grade 10 students, the aim is to propose remedial activities allowing to approach the notions related to this topic, namely the notions of equality between two expressions and solution of an (in)equation, since numerous research works report about students’ difficulties to grasp these notions. The hypothesis underpinning the scenario is that Alnuset, offering dynamic representation of the relationship between x and f(x), respectively independent and dependent variables, as well as the possibility to represent this relationship in different registers, will contribute to a better conceptual understanding of these notions.

The scenario is organised around three units. In the first unit, the students explore the new environment through initial activities about the notion of function and functional (in)equation. The second unit is devoted to exploring whether 2 expressions are equivalent or not. The last unit leads the students to “discover” different techniques for solving equations and inequations with Alnuset. The activities take advantage of the Alnuset potentialities to represent dynamically relationships between expressions and to articulate a representation of algebraic expressions on algebraic line and their graphical representation. Thus, ALNUSET will be also used to introduce solving equations and inequalities from both, algebraic and graphical points of views.

Structural aspect of algebraic expressions (familiar)

Structural aspect of algebraic expressions (familiar)

- Pretest
- Learning
  - Introduction to tree representation
  - Conversion RNL-RT
  - Conversion RSL-RT
  - Treatment in RT
- Assessing
- Posttest

Passwords

Password to view ●●●●●●●● Password to edit

Structural aspect of algebraic expressions (familiar)

Identity

Title

Structural aspect of algebraic expressions (familiar)

Authors

J. Trgalova, H. Chaachoua - MeTAH, Grenoble (France)

Subject domains

- mathematics

Topics

- algebra

Language

English

Country

France

Keywords

- numerical expression
- algebraic expression
- representation system
- tree
- Aplusix

Description

This scenario describes an innovative approach to the algebraic expressions through an introduction of a new representation system: a tree representation. It makes use of the Aplusix software, which allows to represent algebraic expressions either in symbolic algebraic language (usual representation), or as a tree. Both representations can be displayed on the screen at the same time as well.

The scenario is organized in two parts: (1) learning, (2) assessment.

The learning part is divided itself into 4 units: (1) introduction to the tree representation system (RT), (2) interplay between natural language representational system (RNL) and RT, (3) interplay between symbolic language representation (RSL) and RT, and (4) treatment tasks in RT.

The activities are designed to be done either in the traditional paper - pencil environment or in the computer-based environment provided by Aplusix software.

Introduction to algebra: structural sense of expressions (alien)

Introduction to algebra: structural sense of expressions (alien)

- Initial Test
- Didactical cycle 1: Familiarization
  - Phase 1: Introduction to Aplusix
  - Phase 2: The equivalence sign
  - Phase 3: Discussion
- Didactical cycle 2: Structure of natural numbers
  - Activity 1: The commutative law
    - Phase 1: Treatments in TR
    - Phase 2: Discussion
    - Phase 3: Conversions TR-SR
    - Phase 4: Report
  - Activity 2: The associative law
    - Phase 1: Treatments in TR
    - Phase 2: Conversions TR-SR
    - Phase 3: Discussion
- Didactical cycle 3: Syntactical skills
  - Phase 1: Conversions SR - TR
  - Phase 2: Computing on the tree
  - Phase 3: Comparision TR - SR
  - Phase 4: Discussion
- Didactical cycle 4: Towards a structural reading
  - Phase 1: Conversions SR- NL and TR- NL
  - Phase 2: Conversions NL - SR and NL-TR
  - Phase 3: Discussion
  - Exercises
- Final test
- Final report
- Delayed Test

Passwords

Password to view ●●●●●●●● Password to edit

Introduction to algebra: structural sense of expressions (alien)

Identity

Title

Introduction to algebra: structural sense of expressions (alien)

Authors

L. Maffei, M.A. Mariotti, C. Sabena - UNISI

Subject domains

- mathematics

Topics

- arithmetic
- algebra

Language

English

Country

Italy

Keywords

- Aplusix
- didactical cycle
- registers of representation
- tree representation
- equivalence
- additive and multiplicative structure of a number
- structure of a numerical expression
- feedback signs

Description

The PP proposes an introduction to syntactic aspects of algebraic thinking through the manipulation of numerical expressions in structural terms, with the use of Aplusix software. The possibility of identifying a structure in an algebraic expression is supported by the innovative representation given by the software, the tree graph, together with the standard representation.

The types of activities involve three systems of representation: natural language (NL), standard representation of expressions (SR), and the tree representation (TR).

Modelling in Casyopee (alien)

Modelling in Casyopee (alien)

- Didactical cycle 1
  - familiarization
  - Optimization Problem 1
  - Discussion 1
  - Optimization Problem 2
  - Discussion 2
- Didactical cycle 2
  - Optimization Problem 1 - revised
  - discussion on parametrization

Passwords

Password to view ●●●●●●●● Password to edit

Modelling in Casyopee (alien)

Identity

Title

Modelling in Casyopee (alien)

Authors

M. Maracci, M.A. Mariotti

Subject domains

- mathematics

Topics

- algebraic model of geometrical problems

Language

English

Country

Italy

Keywords

- Geometry
- Modelling
- Algebra
- Variable
- Calculus
- Function

Description

The PP is meant to exploit the semiotic potential of Casyopée to consolidate the notions of variable and function, through modelling activities where geometrical problems are treated with the mathematical tools of calculus. A critical reflection on the modelling process itself will be in focus as a general didactical objective.