IL NUOVO CIMENTO Vol. 33 C, N. 3 Maggio-Giugno 2010
DOI 10.1393/ncc/i2010-10628-7

Colloquia: MPTL14

On the use of new methods and multimedia

S. Feiner-Valkier([1]) and E. Sassi([2])

([1]) *Eindhoven University of Technology - The Netherlands*
([2]) *Università di Napoli "Federico II" - Napoli, Italy*

(ricevuto il 30 Novembre 2009; pubblicato online il 27 Luglio 2010)

Summary. — In the STEPS project the working group WG2 studied "New teaching and learning methods" and "The use of new multimedia". Both were surveyed in Bachelor and Master studies of all STEPS members An inventory among universities and alumni on tools, software, programming languages and the importance of transferable skills was made. A list of categorized methods, tools and transferable skills resulted. The WG2 evaluated MultiMedia (MM) with the MPTL group. In 2009 the project STEPS TWO started. The WG2 focuses on project-based and student centred learning, also trying out some best practice materials with students and teachers. We address some problems found in categorizing and evaluating methods and materials We describe some didactical aspects and conditions for an effective integration of MM.

PACS 01.50.-i – Educational aids.
PACS 01.50.F- – Audio and visual aids.

1. – Introduction

STEPS TWO (Stakeholders Tune European Physics Studies TWO) is an academic network of 66 European universities of 27 countries and 7 associated partner universities and is a continuation of STEPS ONE (active during 2005-2008). The aim of the network is to support the physics departments of these universities with the introduction of the Bologna process and to stimulate the quality of teaching and learning with respect to methods, materials and teacher education.

STEPS TWO has three working groups, one on physics curricula, one on new methods and materials and one on teacher education. In this paper we will concentrate on the work on new methods and materials, where we will present the results and conclusions from STEPS ONE and where we will give an outlook to the future activities of STEPS TWO.

2. – STEPS ONE project

The STEPS ONE project had 5 working groups, each of them an executive group of 5 members. This executive group of the working group on new methods and multimedia materials focused on three activities. First, they did an inventory on new methods among the members of the project; second the individual members of the executive group made a contribution to the evaluation of multimedia materials by the MPTL-group and third, they did an inventory among universities and alumni on the use of tools, software and programming languages and the importance of transferable skills. In the following subsections, the results of these activities will be summarized.

2·1. *Inventory on new methods.* – The inventory on new methods resulted in a database with 68 references to universities with new methods (EUPEN, 2005). In most cases it refers to single class activities, in some cases to a whole course. Few universities or physics departments have introduced a completely new approach in education. The database is arranged according to the following categorization:

– Distance and blended learning: (22 Ba and 14 Ma studies).

– Problem based learning and project oriented learning: (34 Ba and 45 Ma studies).

– Student centred learning and peer instruction (19 Ba and 22 Ma studies).

This database represents a valuable collection of places where new methods are applied and it can serve the physics community as an inspiring source for new information.

2·2. *Evaluation of multimedia.* – Members of the executive group of the working group on new methods of STEPS ONE made their contribution to the evaluation of multimedia materials of the MPTL group (MPTL, 2009). During the first year, this evaluation concerned multimedia on Electricity and Magnetism (MPTL, 2006). This was followed by evaluations on Solid State Physics and on Waves and Optics (to be published MPTL, 2009).

The evaluation procedure is done according to a specific list of items and each multimedia product is assessed by at least two persons. The materials are assessed on correctness of the physics content, user friendliness, multi functionality, level of target group, level of didactical instruction and explanations and effectiveness of handling a problem. A short list of these multimedia materials from MPTL, which contains evaluated good quality material is listed on the STEPS ONE website (EUPEN, 2005) and contains materials in the following fields: Classical Mechanics, Electricity and Magnetism, Waves and Optics, Thermodynamics, Quantum Physics and Solid State Physics.

2·3. *Inventory on tools, software, programming languages and skills.* – STEPS ONE did an inventory on tools, software, programming languages and transferable skills among the universities of the project and also among alumni of these universities. A list of transferable skills was constructed based on the results from the TUNING project (TUNING, 2007). This resulted in a response from 68 of the representatives of the universities from the project and from in total 134 alumni graduated from 16 universities in 11 different countries.

There was a strong correlation between the answers of the alumni and those of the representatives on the use of tools, software, programming languages and transferable skills (EUPEN, 2005). The results show a clear preference for the use of MatLab as standard software, LabView, Mathematica and Maple as computer algebra, and C++ and Java as programming languages, both for Bachelor and Master studies. Regarding the importance of transferable skills, both alumni and university representatives valued these skills as important or very important. Skills like Teamwork, Independent working, Result oriented attitude, Analytical thinking, Flexibility, Initiative, Communication and Focus on customers were evaluated. The minimum score was 3.8 on a 5 point scale; the maximum score 4.7 on this scale

Although the response group of alumni is restricted to a limited number of countries, we may conclude that there is no contradiction between the results for the importance of transferable skills. It shows that transferable skills are important in all different types of professional environment for physics alumni.

3. – Discussion on STEPS ONE project

The use of new teaching and learning methods is widely scattered over the various countries that were partner in STEPS ONE. New methods occur both in Bachelor and in Master studies. In most cases these methods are restricted to a particular class or a few classes. We did not gather any information on the necessary tools for universities to introduce these methods or the didactical reasons to choose for a particular method.

The importance of transferable skills was confirmed by the response from alumni. However we did not gather any information on the way how these skills are imbedded in the education program.

One of the most important experiences during STEPS ONE was the fact that we were confronted with the problem of definitions. For instance the definition of various new methods is not straightforward and sometimes related to the teaching practice in every country. New methods can be applied without any new multimedia or the other way around: new multimedia can be applied in a traditional teacher centred learning environment.

As far as STEPS ONE, we succeeded in making a useful categorization for the new methods and we did make a start in selecting and reviewing multimedia materials.

The data are available on a website (EUPEN, 2005); however, to present the data on a clearly defined way, we need to have a suitable list of indicators in general terms and in terms of didactical parameters. One aim of the follow up project STEPS TWO is to get more detailed information about practical and didactical implications of new methods and materials.

Try-out of materials turned out to be very difficult, because in a certain existing teaching practice it is difficult to find time and opportunity to test new materials. This is even more difficult or even impossible for trying out a new method of teaching. So one aim of STEPS TWO is to gather this kind of information from existing practice.

Another conclusion from STEPS ONE is that it turned out to be very difficult to reach alumni in every country represented in the project. Only in few countries there is an official alumni system administrated by the university.

4. – STEPS TWO

STEPS TWO started in 2009 as a follow-up project for a period of 3 years. The project has three working groups, one on "Physics Curricula", one (WG2) on "New Methods and Multimedia Materials" and one on "Physics Teacher Education". In this paper we will only discuss the work of the group on "New Methods and Multimedia

Materials". This group consists of 34 members from 30 different European countries; several of them are also active members of the MPTL group.

4˙1. *Aims of STEPS TWO.* – The WG2 of STEPS TWO project will focus on "Student Centred Learning", in particular "Problem Based Learning" and "Project Oriented Learning". Data will be gathered on detailed information on the applied method of teaching combined with the use of multimedia or other special materials. Also the development of transferable skills by applying new methods will be addressed as well as a description of the necessary tools for universities to introduce these methods and/or materials.

Concerning MultiMedia materials the working group will continue to take part in the evaluation of materials together with the MPTL group. For the presentation of results on a website in a way to enlarge the accessibility of the material, the working group will develop evaluation items in particular those related to didactical aspects. An outline for a description of didactical aspects will be given in **4**˙2. More in detail the description of didactical potentialities and advantages of multimedia material will be presented in **4**˙2.1; a list of indicators in **4**˙2.2; the conditions for integration of multimedia in education in **4**˙2.3; a plea for a Community of Learning and Practice about Multi Media in education in **4**˙2.4.

4˙2. *How to characterize a MM resource for physics education?* – Here the focus is on discussing some indicators to describe didactical aspects and conditions relevant to the introduction of MM and their integration in physics education in standard educational contexts. These indicators can be useful to help people who intend to use MM, to facilitate the try-outs of such materials and also to help searching and selecting them. As said above, in STEPS-ONE there was a problem of definitions, for instance of "new methods" and MM. So it may be useful to recall a couple of definitions of MM from dictionaries, *e.g.*—a combination of moving and still pictures, sound, music and words, especially in computers or entertainment;—use of computers to present text, graphics, video, animation and sound in an integrated way. These general definitions have been interpreted in many ways, becoming wider and wider.

In the MPTL 14 meeting in Udine a large variety of interpretations is present, the vast majority being linked with results and proposals from Physics Education Research (PER). In the Themes/Tracks of this meeting and in the contributions presented, two main areas are present One refers to the main strategies and approaches qualified by PER:

- Inquiry based Learning
- Modelling activities
- Real-Time, Remote, Virtual Laboratory
- Evaluation of Learning Outcomes.

The other one refers to Tools, Programming and Services supporting the development and management of MM. In this paper we don't discuss the aspect of MM regarding the benefits of Scientific Tools and Programming Services or the systems using e-learning.

Marisa Michelini at the Opening Session has shown how large and varied the addressed contents are: many belong to those basic physics concepts perceived as difficult ones by students and teachers (*e.g.* e.m. induction, waves, fictitious forces, ...); others are not commonly taught topics, (*e.g.* history of physics, Boltzmann factor, net of diverse types of labs, atmospheric physics, ...). The students' age range addressed is from primary education (a novelty for MPTL) to secondary school to university and beyond. Also teacher education is considered as well. The variety of MM interpretations emerges also from the 5 Workshops offered (*e.g.* Remote Lab: Different approaches; Web-Delivered Interactive Lecture Demonstrations; ...) and from the contributions selected for presentation.

4·2.1. Didactical Potentialities and Advantages of MM. A MM instrument should be intended as a factor of educational innovation. The most important aspects to be clarified and exemplified in order to foster its adoption and its fruitful use refers to its didactical potential. A teacher with little experience but with an interest in using this type of educational resources in its class practice will certainly need a variety of information ranging from how to find MM resources of a high quality, to how to deal with them from a technical point of view to how to organize the learning process. However a good understanding of the educational potential for innovation of a MM material including its advantages and its possible limitations is perhaps the most important preliminary factor to guide the selection and the use of a specific MM.

Didactical potential may be a generic term. Here we propose a categorization of dimensions that are important for physics education. The main dimensions of the "MM Potentialities/Advantages Space" can be summarised as follows.

– Addressing Common Learning/Teaching Difficulties and

– to "see" the "invisible" (particularly important for a dynamic process).

These potentialities and advantages can be attributed to several educational approaches, tools and proposals but MM have them with great strength The capability of addressing the main robust/common learning difficulties encountered by students and thoroughly addressed by PER is important when the improvement of the quality of learning is amongst the main goals. Analogously the use of dynamic images can help students to "see" and construct mental images of the evolution of dynamic systems. It is true that equations and formulas summarise all information needed to describe a phenomenon. R. Feynmann liked to say that by looking at Maxwell equations one can see the complete e.m. phenomenology. But this capability is not common, it is required to be able to connect abstract mathematical representations with real-life phenomena, experiments and data trends with mental pictures, and so on. Students, specially young ones, usually have not yet developed powerful abstraction skills, so to provide them images, specially dynamic ones, can help their scientific imagination and strengthen it.

– Synergic combination of diverse types of Laboratory.

In particular the variational approach (...what happens if ...changes?) is powerful in many moments of the construction of knowledge, *e.g.* in:—Lab-work where the observation of consequences of variations in experimental setting, variables, parameters can foster a deeper understanding of the explored phenomenon;—Simulations where it can clarify how relevant are the variations made (*e.g.* what physics appears if the square power in the $1/r^2$ laws is changed);—Links amongst Phenomena and Models and distinction between using a model built by others from building a model by oneself.

– Facilitating power for the integration of diverse types of knowledge.

The cognitive skills that foster a synergic integration are not often sufficiently valued in current teaching practice. They refer to integrate:

– Perceptual knowledge (*e.g.* experiments based on the link to perception)

– commonsense knowledge (*e.g.* eliciting naïve ideas and reasoning strategies)

– abstract representational knowledge (*e.g.* time graphs of measures and multi-representation of the same data)

– experimental knowledge (*e.g.* experiments' settings and measures)

– variational knowledge (*e.g.* analysis of the consequences of changes in variables and parameters)

– correlative knowledge (*e.g.* relating different representations of the same phenomenon and comparing experiments and models).

Another great potentiality relates to the organization of the learning environment, *e.g.* the use of the same MM by a small group of students (2–3), as a trigger for peer learning, sharing of diverse viewpoints, elicitation of naïve ideas and reasoning patterns. As for other types of collective learning, a coherent set of activities based on MM can help the learners to overcome common difficulties in the construction of a long-lasting physics knowledge.

4·2.2. Didactical Indicators for MM. The educational potential discussed above could be further articulated into three classes of didactical Indicators which should be key elements of the presentation/description material associated to a MM resource: SCOPE (refers to the contents addressed and their level of details), PEDAGOGICAL EFFECTIVENESS and TRANSFORMATION POTENTIAL (focusing more on possible impacts of the specific MM on the learning/teaching processes)

1) SCOPE (S) The range of dimension is a continuum, going from MICRO or local, *i.e.* a narrow/specific topic of a disciplinary area, to MACRO or global, *i.e.* a large subject, a combinations of many topics, a whole course. Usually information about S is given in the description of the MM.

2) PEDAGOGICAL EFFECTIVENESS (PE) has to do with the capability of a MM to be a vector of pedagogical innovation aimed at improving the quality of the learning process from a variety of points of view: supporting inquiry and exploratory learning, bridging the traditional gaps in scientific education (between phenomena and representations, theory and practical application . . .), enhancing students' motivation, making learning more persistent, building bridges between different disciplines or areas of knowledge and so on.

3) TRANSFORMATION POTENTIAL (TP) has to do with the capability of a MM to be a vector of cultural innovation involving new visions of the learning process. This typically requires a redesign of old schemas and approaches, new organizational settings, new teacher competencies and roles, new relationships with the syllabuses, new assessment procedures and tools and so on.

Usually scarce or no information is given as far as PE and TP are concerned, currently the focus is on how to run technically the MM and how user-friendly it is. So there is not much help for the inexperienced teacher with respect to the last two indicators both relevant from the viewpoint of an educator who wants to decide if and how to use MM materials to help students learn. As an example, if somebody is searching the web for some specific MM, *e.g.* Young experiments on double slit interference, it is given back a long list of animations, simulations and models to choose from, the content being sufficiently described (so the SCOPE is addressed) but very little or nothing about pedagogical matters or integration in the curricula is suggested So there is little help for the teacher in the critical tasks of understanding the pedagogical meaning of a MM resource and designing a learning process which, while necessarily referred to his/her previous experience, goes far beyond it since a substantial reshaping of the traditional teaching/learning path is typically required.

4˙2.3. Integration of MM in educational practice. A issue to be addressed is how to realise a not occasional integration of MM in standard educational contexts. Such an integration is at the same time a powerful opportunity to improve the quality of teaching and learning processes but also a great challenge, given the variables, conditions and risks affecting the effectiveness of a non sporadic integration of MM materials.

Several boundary conditions have to be taken into account. The main ones can be summarised as follows:

a) Integration in curricula and syllabuses This issue is especially important in those countries where the contents' program is decided centrally by the national education authorities, the goal of "covering" the program is a main one and interdisciplinarity is not much practiced.

b) Students' pre-requisites (mathematical, relational, technological/instrumental).

c) Organizational and physical contexts of the school; socio-cultural contexts of students, families and environment; geographical and local resources.

d) Teachers' competences (*e.g.* content knowledge, pedagogy and sociology, pedagogical content knowledge, communication, technological and instrumental knowledge).

e) Collaboration within the school, *e.g.* headmaster support; willingness by colleagues to value such type of innovation, to commit to invest extra time and effort to re-design traditional paths, to modify (at least partially) schedules, syllabuses, assessment tools and procedures.

In the case of a sporadic use of MM, for instance of few simulations or dynamic images, to cope with the above boundary conditions is less compelling, given the occasional character of such use; moreover, this use of MM, even if well received by the students, does not guarantee the construction of a solid and long lasting physics knowledge. On the contrary, the impact of such conditions is very important when MM are used as a not minor systematic component of the learners' activities, or as a complete course.

To ease an effective integration of MM in learning and teaching processes, it is also required the capability of orienteering in the world of MM, a large and rapidly expanding one where the materials have diverse origin, *e.g.* Physics Education Research groups, educators and commercial market. As for other areas, the web is a gigantic depository where materials of a very different quality are offered.

Amongst the orienteering tools, database and collection of reviewed and commented MM can be very useful, not only to encourage the novices, for instance teachers willing to use MM but also to support experienced teachers. The catalogues of MM become more effective when the information about the recommended specific material are enriched by educational hints and comments aimed at facilitating their integration in standard contexts, since it is not enough to simply propose MM (or any other ICT based materials) to the learners to improve the teaching-learning processes.

Other than in the description of the MM, also in the design process this enrichment is very important. It should focus on the above SCOPE, PEDAGOGICAL EFFECTIVENESS and TRANSFORMATION POTENTIAL and on the main Common Learning and Teaching Difficulties of the addressed content (ex. Bibliography by Duit, 2007) The taking into account of the above dimensions in the design process will help in reaching the goal of a pedagogically qualified MM by offering more articulated materials from a didactical viewpoint.

Another useful component of such enrichment, that will help novice and experienced teachers, refers both to hints for key questions to ask the learners and to suggestions for possible reactions to learners' ideas and reasoning schemas, especially when they conflict with the disciplinary knowledge.

To help in building such an enrichment it can be very useful to take into account both a well thought "summary" of PER results and proposals and the experiences of MM uses in standard educational contexts, for instance in the form of emblematic reactions of teachers and students.

To avoid misunderstanding, the proposed "enrichment" is to be intended as a range of suggestions the teachers decide about, certainly no as recipes since already too many gospels (often ICT based ones) have been preached as "solutions" to educational problems.

About an effective, not sporadic integration of MM based activities in ordinary contexts, it seems reasonable and plausible to agree on three main levels of questions to be addressed:

a) which actions should be undertaken to best foster/ease educational innovation via MM

b) how to foster open discussion of possible/plausible problems in choosing and using MM

c) how to support the teachers (pre-service and in-service ones), specially when they operate on the field.

To help addressing all these issues, some actions can help. They, facilitated by a joint effort of people involved in producing and reviewing MM for physics education, are needed if the main goal of the use of such materials is to improve the quality of the current educational practice.

One action is to increase the production of MM designed according an explicit awareness of the importance of the pedagogical qualification mentioned above. Another action is to produce additions coherent to such a viewpoint in the recommended catalogues of already existing MM Both actions require at least two improvements:—an increase of attention by the MM producers to the PER results and proposals;—a set of research oriented try-outs of some MM in standard educational contexts aimed also at collecting feedback from the teachers and students involved. As said above, one goal of STEPS-TWO Working Group 2 is to collect and analyse data from some try-outs of MM at different learner age (Secondary School, Bachelor, Master and so on). These actions will help to address the issue of an observed, well known resistance in using MM which is frequent amongst teachers. To discuss the main problems in choosing MM and engaging the learners in non sporadic activities, is appropriate and urgent. An open discussion between MM producers, teachers, students, headmasters and researchers in Physics Education would benefit from real experiences of MM use in standard contexts. Specially comments and feedbacks from teachers and students can spotlight difficulties to be addressed and potentialities to take advantage of. Such open discussion can be usefully done in the framework of a Community of Learning and Practice (cfr. in the following).

Last but not least the teachers (both pre-service and in-service ones) do need to be supported and facilitated in the process of becoming familiar with PER results (ex. ICPE, 1998 and 2008), also for fostering a MM based educational innovation.

4·2.4. Community of Learning and Practice about MM for physics education. For all the above three levels of questions, the realisation of a Community of Learning and Practice (CoLP) can act as a powerful tool. The rationale of such a community is the sharing of problems, experiences and solutions that occurs amongst the participants and the practices that emerge or evolve when people who have common goals interact as they strive towards those goals. The most common case are the communities of practitioners into which newcomers enter and aim at acquiring the practices of the community. The members of a CoLP share an interest for something they do or intend to do; they learn more about how to do it better as they interact. The CoLP has an identity defined by a shared domain of interest; to be a member implies a commitment to the domain and to building relationships that enable to learn from each other. The community develops a shared repertoire of resources including vocabulary, concepts, experiences, stories, tools, problems, ways of addressing recurring problems, ... in short "a shared practice".

In the case of MM for Physics Education, since the interested people are very often apart, the CoLP is a *virtual community* sharing information, problems, experiences, resources, solutions and, even more important, building new awareness of problems, new answers to problems and new knowledge. The CoLP is at the same time a place where knowledge is generated and a repository of evolving knowledge. The building of a CoLP is not just matter of choosing the right technology to communicate (although the type of functionalities provided by a platform may play an important role). It is necessary to build the social skills requested for being an active member of a community and to benefit from it. These skills include the awareness of the commitment to the community, the valuing of the membership; the capability of concise and converging communication; the will to listen and contribute; the belief that diversity is richness and so on. Sometimes to acquire such skills requires time.

The members of the MM CoLP will engage in common activities about the use of MM in Physics Education, find help and mutual support in being members of such a community, share pedagogical plans, results of try-out in ordinary contexts, products, schema for lab-work and class activities, assessment procedures and tools, references and related comments Through all such activities they build relationships enabling them to learn from each other.

In order to realise a CoLP dedicated to educational use of MM there is a need of joint efforts of institutions, groups, agencies The MPTL and COMPADRE groups can be important actors of such process with their capital of expertise, as well as the STEPS-TWO activities described above. The call for an MM CoLP seems to be both a natural extension of what has been addressed in the Udine MPLT14 and an appropriate objective for the future MPTL meetings.

5. – Conclusions

An inventory of new methods of teaching and learning in Europe is made during the project of STEPS ONE. We made a contribution to the inventory of multimedia materials and the evaluation of these materials in collaboration with the MPTL group from Europe and COMPADRE from the USA. STEPS ONE gathered data on the use of scientific programs, languages and software and the importance of transferable skills among European universities and alumni Results can be found on the STEPS TWO website. The continuation of the project called STEPS TWO gives us for another three years the chance to continue our work with new methods in teaching and learning and the use of multimedia in a more specific and detailed way regarding the meaning of these methods in life-long learning perspective; regarding the characteristics and the potentials of MultiMedia in this perspective and the way they contribute to the development of transferable skills.

In this respect a possible way of characterising MM for science education (physics in particular) has been discussed. Currently the description of such MM does not offer much about the potentialities for a deep innovation of the learners' activities and a possible consequent more improved understanding of conceptual nodes of physics.

To specify the space of the didactic potential of MM, three dimensions-indicators are proposed:

1) SCOPE relating to the content addressed (usually some information is given in the description);

2) PEDAGOGICAL EFFECTIVENESS referring to pedagogical innovation from a variety of standpoints (*e.g.* inquiry based learning; links between phenomena, abstract representations, models and theories; students' motivation; bridging different content areas ...);

3) TRANSFORMATION POTENTIAL relating to cultural innovation and new visions of the teaching-learning process (*e.g.* redesign of approaches and contents, teachers' competencies and roles, learning environments, assessment procedures, ...).

Some main boundary conditions to take into account for a non sporadic integration of MM in standard educational contexts have been spotlighted, *e.g.*—integration in the syllabus;—teachers' competences;—students' pre-requisites;—organizational and physical contexts of the school;—socio-cultural context of students, their families and environment; geographical and local resources;—collaboration within the school.

An enhancement of both the pedagogical design of MM and their description according to the above didactic indicators, is strongly desirable. Actually is a kind of a must, to help in knowing more both the educators novices with respect to the use of MM and who have already some experience Finally the building of a Community of Learning and Practice for MM in Physics Education is recommended, to build a shared repertoire of vocabulary, concepts, experiences, stories, tools, problems and solutions, ways of addressing recurring problems, pedagogical plans and so on. Virtual professional communities appear as a key factor for the teachers professional development; their establishment should be envisaged as a joint effort of institutions and groups involved in designing, reviewing and recommending MM.

* * *

We thank G. Olimpo, Istituto Tecnologie Didattiche, CNR, Italy, for fruitful discussions and comments.

REFERENCES

Duit, R. (2007). Bibliography—STCSE (Students' and Teachers' Conceptions and Science Education)
`http://www.ipn.uni-kiel.de/aktuell/stcse/download_stcse.html` accessed 2009.

Eupen (2008), `www.eupen.ugent.be`, accessed 2009.

ICPE (International Commission on Physics Education, 1998 and 2008) Connecting Research in Physics Education with Teacher Education, Volume 1, Volume 2. Available at `http://web.phys.ksu.edu/icpe/Publications/index.html`, accessed 2009.

MPTL (2006), `http://www.mptl.eu/reports_files/Rep_Recom_ElectMag_2006.pdf`, accessed 2009.

MPTL (2009), `www.mptl.eu`, accessed 2009.

STEPS TWO (2008), `www.stepstwo.eu`, accessed 2009.

TUNING (2007). Reference Points for the Design and Delivery of Degree Programmes in Physics.