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Development of Astronomy Educational Resources: the Case of Universe Awareness

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A coloro che hanno creduto in me...

Indice

Abstract

In this thesis we will study astronomy as a means to spread science education. Moreover, we will illustrate how the popularisation of science, especially if introduced during childhood, plays an important role in improving the quality of life of the individual and the growth of the society in the long run, in particular for developing countries. Specifically, we will discuss an international astronomy education and outreach programme: Universe Awareness - UNAWE. This programme, which has been approved by the International Astronomical Union, involves over 50 countries and has more than 800 collaborators, including astronomer educators and teachers. UNAWE deals with popularising astronomy and scientific thinking, through activities aimed at teachers and children aged 4 to 10, focusing especially on those from disadvantaged backgrounds. In this thesis we present the scientific basis that supports the UNAWE project, and examine the means and goals of the programme. We will in particular focus on the collection, production, review and distribution of high quality astronomy educational material. We will explain how UNAWE has chosen to use Open Educational Resources with the aim of reaching a broader audience, while increasing the quality of developed activities. Indeed, the scientific and pedagogical quality of UNAWE activities is guaranteed thanks to a peer-review process, in which both astronomer and educator are involved. In addition, we will discuss the new and unprecedented online UNAWE platform, which has been created to respond to problems related to the research of material on the web, and also to ensure the quality of this material while keeping it constantly updated. Finally, we contextualise the evaluation programme performed by UNAWE, which is of fundamental importance to assess the effectiveness of the proposed educational activities. We will conclude with some ideas for assessing the impact and the long-term importance of the UNAWE project.

Sommario

In questa tesi andremo a studiare l'astronomia come mezzo per diffondere l'educazione scientifica. Inoltre illustreremo come la divulgazione scientifica, specialmente se introdotta nell'infanzia, giochi un ruolo importante nel migliorare la qualità della vita dell'individuo e la crescita della società nel lungo periodo, soprattutto per i paesi in via di sviluppo. Discuteremo in particolare di un programma internazionale di educazione e divulgazione scientifica in astronomia: Uniwerse Awareness – UNAWE. Questo programma, approvato dall' Unione Astronomica Internazionale, coinvolge oltre 50 paesi e più di 800 collaboratori tra astronomi, educatori ed insegnanti. UNAWE si occupa di diffondere l'astronomia e il pensiero scientifico attraverso attività rivolte ad insegnanti e bambini tra i 4 e 10 anni, concentrandosi specialmente su quelli provenienti da ambienti svantaggiati. In questa tesi presenteremo i fondamenti scientifici a sostegno del progetto UNAWE, esaminandone mezzi e obbiettivi. Ci focalizzeremo particolarmente sulla raccolta, produzione, revisione e disseminazione di materiale didattico astronomico di qualità. Spiegheremo come UNAWE abbia scelto di avvalersi di Risorse Educative Aperte, con l'obbiettivo di raggiungere un più vasto pubblico possibile permettendo inoltre l'incremento della qualità delle attività sviluppate. Infatti la qualità scientifica e pedagogica delle attività UNAWE viene garantita grazie ad un processo di peer-review nel quale sono coinvolti sia l'astronomo che l'educatore. Tratteremo in aggiunta la nuova e unica al mondo piattaforma online di UNAWE, creata per rispondere alle problematiche legate alla ricerca del materiale sul web garantendo inoltre qualità e costante aggiornamento. Contestualizzeremo infine il programma di valutazione svolto da UNAWE che risulta di fondamentale importanza per valutare l'efficacia delle attività didattiche proposte. Concluderemo con alcune idee per valutare l'impatto e l'importanza a lungo termine del progetto UNAWE.

Introduction

To carry out an original thesis in didactics and the popularisation of my passion, astronomy, I asked to collaborate with one of the major international centres that deals with these topics: Universe Awareness – UNAWE.

UNAWE is an international project that was founded in the Netherlands in 2005, at the University of Leiden, thanks to the idea astronomer Professor G. Miley. This programme operates in many countries around the world, involving all sectors of education. It aims to exploit the beauty, the charm and the immensity of the universe to inspire children aged 4 to 10, particularly those from developing countries and disadvantaged backgrounds. Besides wanting to encourage children to continue their education in science, the goal that UNAWE wants to achieve through the teaching of astronomy is to give the children a sense of perspective and self-consciousness, in order to open up horizons that go beyond the world in which they live. In addition, in The Netherlands, a country which has historically been the birthplace of famous astronomers, astronomy has become an important cultural aspect that is now part of tradition. In fact, The Netherlands is one of the countries that invests the most into the field of astronomy, both in research and development, as well as in outreach.

Therefore, when the UNAWE team has agreed to let me work with them for my thesis project, I considered it as a unique opportunity to grow professionally in this area, to learn how to popularise science with dedication, and as a preparation for developing new activities. Furthermore, I have considered it a chance to more closely see how an international organisation works and to gain experience in a multicultural environment.

Ultimately, during the last six months I have worked with the UNAWE team in Leiden under the direct supervision of the international manager Dr. P. Russo and the Professor G. Miley. Moreover, my work has developed in several phases. First of all I had to get familiar with all of the educational resources, the website, the material and the various activities carried out by the group. Afterwards, the real work began: the work aimed at thesis writing.

Indeed, I have conducted an accurate literature search to gather and put together all of the scientific sources which give strength, credit and support the UNAWE project from different points of view. This literature review has been an important task because for the first time in one document, all of the foundations and principles upon which UNAWE is based have been collected. This document will be useful and inspiring for other projects of this type.

In addition to this task, as well as observing and talking to experts in the sector and studying specific texts, I have learned the pedagogical objectives, and the means to achieve them, suitable for UNAWE' s specific audience of young children. In fact, at the end of this phase of study and material collection, thanks to the existing resources and also by making use of the support of experienced UNAWE' s collaborators, I have prepared a detailed structural model for the activities' development. This is, in practice, a guideline to follow in order to develop educational activities in the best way and with the objective of making them clear and feasible to use in classroom with students.
After all of this and as a result of the work done so far, I carried out a review of all existing educational activities. In effect, this was necessary to verify that the activities were designed according to the structural model and to ensure their high quality. Therefore, as a referee, I have revised, corrected and improved every educational resource. All of this was done in order to ensure the accuracy and completeness of the scientific content, and also to ensure that the pedagogical objectives and the language were suitable for children aged 4 to 10. In essence, I put into practice a peer-review process for the existing activities, as well as for new ones brought to the attention of UNAWE. Moreover, all of the reviewed activities have been corrected by an editorial board.

Consequently, I provide with my work an example of how to bridge the gap between research and practice and resolve issues that can arise from it. However, a further gap has emerged; it is the one linked to the socio-cultural differences between privileged and underprivileged environments. Such differences are reflected on science education. This kind of problem obviously cannot be solved with educational activities, but we have tried to mitigate the problem from a linguistic and cultural point of view to allow everyone to benefit from the UNAWE activities.

At this point, a new phase of my work at UNAWE began. I supported the development, creation and implementation of a new Peer-Review Platform for high quality astronomy educational resources – a platform that is unique in its kind. Indeed, I have performed the task of transforming all of the reviewed, adapted and corrected educational resources into Open Educational Resources (OERs, which are open and freely available). Moreover, my duties involved making sure that all of the links were active, verifying that the images were of good quality and finally entering all of the material in the new platform's repository.

As a final task I started the actual drafting of this thesis and, for completeness, I have also analysed the evaluation programme, which UNAWE is implementing, for the activities and the project. However, the data collection is still ongoing and thus at the moment it is not yet complete. I was still able to examine the data collected so far and formulate an initial general estimate. As a result of this analysis I have suggested to UNAWE to implement a long-term evaluation programme. Furthermore, I have given, for the first time, some practical guidelines and tips (inspired by the study of other educational projects of the past) on how to set up this long-term study for the evaluation of project UNAWE's impact, a study that is likely to be done in the future.

The work done with the UNAWE team has presented several challenges, but also has offered great satisfaction. I like to think that I have contributed in part to improve the world of teaching and popularisation of astronomy through the ideas, analysis and results. This work has also given me an unexpected fulfilment from the employment commitment and efforts. Indeed, with my composition I participated as a co-author of the article Astronomy Educational Resources Peer Review Platform that the international manager Dr. P. Russo is preparing with other UNAWE collaborators for the submission to the Journal of Science Education and Technology [1].

Here I will describe the themes that will be covered in this thesis. We will begin by addressing the definition of science education, a subject that introduces the following chapters and is necessary to understand the context in which this work evolves. It is important to have an idea of how over the years, from the late nineteenth century to the present, the meaning of science education has transformed and evolved, along with the methods of teaching science, to reach the present-day style of education which involves every different but complementary pedagogical styles. In addition, we will see the particular importance of science education. Indeed, science education allows students to develop not only knowledge but also skills and a characteristic ways of thinking, which will be useful throughout their lives and will help them in building a better future, a framework in which astronomy fits perfectly. Thanks to its unique features, astronomy is considered to be a subject extremely suitable to science education and an excellent means to achieve its goals.

Once we have analysed the context, we discuss in detail how the UNAWE project is structured, its history, its activities and its objectives. As we shall see, many researches and studies support this project and its decision to focus more on an audience of children aged 4 to 10, especially from disadvantaged backgrounds.

UNAWE deals with astronomical outreach from every point of view, collaborating on ambitious international projects, providing research articles that can be easily understood by the public on the internet and encouraging the collaboration between teachers and educators from the member countries through an international network. In addition, UNAWE deals with the training of teachers and with the collection and creation of activities which may be used by classes of pupils all over the world.

[1] Russo, Gomez, Cardenas-Avendano & Simionato, 2013, *Astronomy Educational Resources Peer Review Platform*, to be submitted to Journal of Science Education and Technology (ISSN: 1059-0145)

In particular, we analyse the educational astronomy material collected and produced by UNAWE and distributed as OER. Focusing on the results obtained thanks to the six months during which I worked with the UNAWE team, we see the structure model and the guidelines necessary for the development of resources, which are created specifically to meet required high quality standards. Indeed, the guidelines involve the choice of the goals, the design and development of the activity, as well as the content, skills and attitudes to consider. They also give recommendations on the language to use and on how to write the content.
This part, entitled Astronomy Educational Material, along with the following section, which dedicated to the new Peer-Review Platform, form the main body of this work.

At this point we can illustrate the UNAWE Peer-Review Platform. The platform is designed to address the growing difficulty of finding astronomical resources on the web which are suitable to the UNAWE audience, and to address challenge of being assured of their quality and reliability. Therefore, inspired by methods used in scientific research, UNAWE, with the support of International Astronomical Union (IAU), has developed a meticulous peer-review process. This process is overseen by a curator who will decide if the resource in question meets all of the required standards to be published in the platform. In this way, anyone can submit an activity to the attention of UNAWE and, once published in the platform, it will be a resource of high quality and visibility in the world of astronomy education. In addition, all of the successful resources will be translated into various languages while considering the cultural aspects related to each language, and distributed in various formats to reach a wider audience and meet its various needs.

For completeness, we also examine the evaluation programme for the resources and for the project itself that UNAWE has designed and is performing at the moment. As this is still work in progress, it is not yet complete, but it was possible to see the first collected data and draw some interesting conclusions from these. This analysis has led to some ideas and suggestions for the future of the platform and of the evaluation, which we will expose.

Finally, we conclude by shedding light on to the strengths of the UNAWE project and of its objectives, and by suggesting ideas to improve these further in the future. Moreover, we emphasise the importance of this and similar educational projects in the countries where they are carried out. We also highlight how projects such as UNAWE allow not only the teaching of astronomy, but also the popularisation of the scientific method and critical thinking, which are qualities which allow the growth of the individual, as well as of the society to which they belong.

Capitolo 1

Science Education

In this chapter we introduce the concept of science education. We start analysing how, thanks to different types of education, science knowledge is transferred to learners. We discuss why it is important to study science and how it is supposed to be learned to obtain the maximum effect. Moreover we explain that intervene with science education in the pre-university period is important to develop special skills. Skills that help students to take advantage of the acquired science knowledge, improving all aspects of their lives. In addition we expose what are the main challenges in science education and what are the possible solutions to these problems. Finally we emphasise that astronomy fits perfectly in this context, since astronomy is extremely suitable, due to its peculiarities, to science education and as vehicle to reach the goals of science education.

1.1 Definition of Science Education

To have a global view and to fully understand the significance of science education, we start with the definitions of the words education and science.

Etymologically, the word education is derived from the Latin *ēducātiō* (A breeding, a bringing up, a rearing) from *ēdūcō* (I educate, I train) which is related to the homonym *ēdūcō* (I lead forth, I take out; I raise up, I erect) from *ē-* (from, out of) and *dūcō* (I lead, I conduct) [1].
Education in its general sense is the process, the art, the activity and the result of learning and of developing (of leading out) knowledge, skill and judgement [2]. Therefore, education is the set of facts, skills and ideas that have been learned, either formally or informally. They are transferred from one generation to the next through teaching, training, research or simply through autodidacticism [3]. Generally, this transfer occurs through any experience that has a formative effect on the way one thinks, feels or acts [4].

Science (from Latin *scientia*, meaning knowledge) is a systematic enterprise

that builds and organises knowledge in the form of testable explanations and predictions about the universe [5] [6].
In modern use, the word science more often refers to a way of pursuing knowledge, not only the knowledge itself. It is often treated as synonymous with natural and physical science and thus restricted to those branches of study that relate to the phenomena of the material universe and their laws [7]. Unquestionably, science involves the study of various aspects of the natural world around us and it is split into many disciplines and sub-disciplines.

Combining the definitions of education and science we obtain the general meaning of science education, the focus of this chapter. We can consider science education as the field concerned with sharing science content and process with other individuals. The target individuals may be children, college students or adults within the general public. Instead, the traditional subjects included in the standards are physics, life, earth and space sciences [8].

Nevertheless it has taken more than a century to reach this definition of science education. In fact, science education was officially recognised for the first time in 1850, when there was the first person credited with being employed as a science teacher [9]. Since then, science education has travelled a long and difficult road, full of controversies, debates, critiques, reforms and innovations [8].

Throughout the last century, science education slowly began to play an increasingly important role, people have started to understand that science is a powerful enterprise that can improve people's lives in fundamental ways [10]. Despite all the difficulties, science has become a cornerstone of 21st-century education, for this reason paying attention to science education has a fundamental importance at all levels. Knowing this, it is imperative that we teach science well to all children, as science is a critical factor in maintaining and improving the quality of life. Students who learn to talk with peers in scientific ways, for example, tracing logical connections among ideas and evidence and criticising ideas constructively, may employ those skills in other subject areas [10].

1.2 Different Types of Education

It is necessary to distinguish between different types of education. We usually define two general types: formal and informal education.

Referring to the European Centre for the Development of Vocational Training (Cedefop) 2003 as the guideline for the definitions [11]:

- *Formal Learning*: learning typically provided by an education or training institution, structured (in terms of learning objectives, learning time or learning support) and leading to certification. Formal learning is intentional from the learner's perspective.

- *Informal Learning*: learning resulting from daily life activities related to work, family or leisure. It is not structured (in terms of learning objectives, learning time or learning support) and typically does not lead to certification. Informal learning may be intentional but in most cases it is not-intentional (or incidental/random).

Traditionally, formal learning takes place in a school or university and has a greater recognition than informal learning [12]. Formal education is highly institutionalised, bureaucratic, curriculum driven and formally recognised with grades, diplomas or certificates [13]. For curriculum we mean the set of courses and their content which are offered by an institution such as a school or university. In its broadest sense a curriculum may refer to the entire sum of lessons and teachings prepared by the teachers for the students to learn. It is also synonymous to the course of study and syllabus.
Consequently formal learning is characterised by a contiguous education process which necessarily involves the teacher, the students and the institution. There is a programme that teachers and students alike must observe, involving intermediate and final assessments in order to advance students to the next learning stage. This kind of learning confers degrees and diplomas pursuant to a quite strict set of regulations [14]. We clearly deduce that formal scientific education is entrusted exclusively to teachers and professors, which have the certifications and knowledge to perform this task.

On the other hand, informal education is a general term for education outside of a standard school setting. Informal educators work in many different kinds of settings with individuals and groups who choose to engage with them [15]. Moreover the mass media (including television, video games, magazines, etc.), museums, libraries, zoos, after-school groups and other community-based organisations and cultural institutions offer forms of informal education [16]. In fact, informal learning occurs in a variety of places, such as at home, work, youth programmes at community centres, media labs and through daily interactions and shared relationships among members of society [17]. Therefore, it makes sense that we consider informal educators (certified or not) as being experts in a particular field, researchers or just people who have more knowledge and have more experience about certain areas.

Unfortunately it's the acquisition of informal learning which occurs in everyday life that has not been fully valued or understood for a long time [12]. Nevertheless, nowadays both formal and informal learning are considered integral processes for Virtual Human Resource Development, with informal learning the strongest form [18] (Figure1.1).

Even if the definitions of formal and informal education are very precise, the transition from one to the other is not as sharp. There is an intermediate zone, where formal and informal learning interpenetrate in part. For clarity purposes and to understand better this intermediate zone between formal and informal

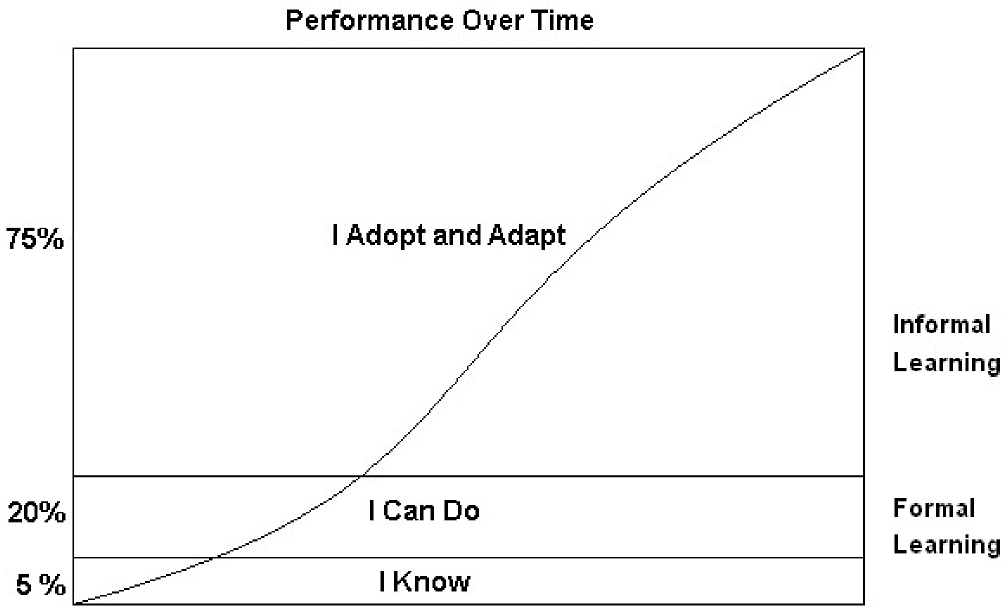

Figura 1.1: Experience indicates that much of the learning for performance is informal (The Institute for Research on Learning, 2000, Menlo Park). Those who transfer their knowledge to a learner are usually present in real time. Such learning can take place over the telephone or through the Internet, as well as in person. A study of time to performance done by S.-A. Moore at Digital Equipment Corporation in the early 1990s [19] graphically shows this disparity between formal and informal learning.

education, we must introduce a third type of education: non-formal education. Non-formal learning is a distinction in learning between formal and informal learning. It is learning that occurs in a formal learning environment, but that is not formally recognised. It typically involves workshops, community courses, interest based courses, short courses or conference style seminars. Ultimately the learning takes place in a formal setting such as an educational organisation, but is not formally recognised within a curriculum or syllabus framework [12].

In conclusion we can distinguish three types of learning [20] [21]:

- *Formal learning* is learning that takes place within a teacher-student relationship, such as in a school system. The term formal learning has nothing to do with the formality of the learning, but rather the way it is directed and organised. In formal learning, the learning or training departments set out the goals and objectives of the learning.

- *Non-formal learning* is instead organised learning outside the formal learning system. For example: learning by coming together with people with similar interests and exchanging viewpoints, in clubs or in (international) youth organisations, workshops, etc.

- Finally *informal learning* occurs through the experience of day-to-day situations. For example, one would learn to look ahead while walking because of the danger inherent in not paying attention to where one is going. It is learning from life, during a meal at table with parents, play, exploring, etc.

For the three forms of learning **officially** defined by the Organisation for Economic Co-operation and Development (OECD) in 2007 see appendix A.

1.3 How to Learn Science

Knowledge of science can enable us to think critically and frame productive questions. Without scientific knowledge, we are wholly dependent on others as experts. On the contrary, with scientific knowledge, we are empowered to become participants rather than merely observers. It is a resource for becoming a critical and engaged citizen in a democracy [10]. In short this implies questions of civic and global importance and integrates diverse modes of enquiry.

For this reason it is important to provide students not only with a deep and personal relationship with subject but also with an understanding that learning science is based on continuous and creative investigation: questioning, mapping, reflection, systematic observation, data analysis, presentation, discussion, modelling, theorising and explaining. Above all, science in practice involves doing something and learning something in such a way that the doing and the learning cannot really be separated. In fact, when students engage in science as practice, they develop knowledge and explanations of the natural world as they generate and interpret evidence. At the same time, they come to understand the nature and development of scientific knowledge while participating in science as a social process. This means that scientific content and scientific process (learning and doing science) can not be separated.

Knowing this, new research points toward a kind of science education that differs substantially from what occurs in most science classrooms today. Science learning can be modelled in important ways on how real scientists do science [10]. Indeed, a common characteristic of all scientific study is the method by which different problems are tackled. The scientific method follows a step-by-step process involving [22]:

- Defining the problem;
- Defining the hypothesis to test;
- Considering the background knowledge and previous work in the field;
- Choosing a method;

- Completing the experiment;
- Recording the observations and results;
- Interpreting the results;
- Drawing conclusions.

Even if the specifics of each step may vary depending on the field of study, the general principle of how the problem is tackled will be similar. In all cases, objectivity is attempted. Moreover experiments are undertaken to add either to one's personal knowledge or the general body of knowledge. For this reason, it is important to be able to communicate the achieved results.

On the contrary, books on science education have often drawn a sharp distinction between scientific content and scientific processes. In fact, contents have been seen as the accumulated results of science—the observations, facts and theories that students are expected to learn. While processes have been seen as the scientific skills that students are expected to master—skills such as designing an experiment, making measurements or reporting results.

As we have seen, we cannot separate scientific content and scientific process. This framework rests on a view of science as both a body of knowledge and an evidence-based, model-building enterprise that continually extends, refines and revises knowledge. This link between content and process is vital because scientific processes almost always take place when students are considering specific scientific content (Figure 1.2) [10]. To highlight how this link between content and

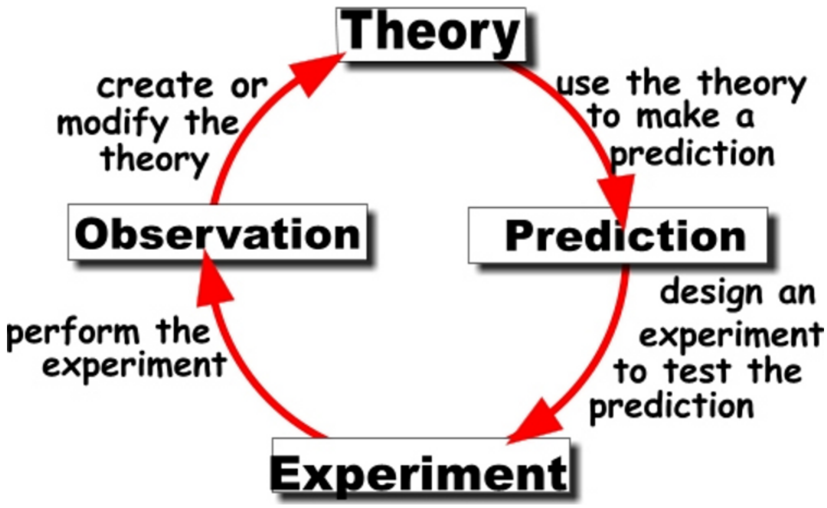

Figura 1.2: This diagram shows that scientific process and scientific content are strictly linked.

process is inseparable, we define and describe four learning strands that encompass the knowledge and reasoning skills that students eventually must acquire to be considered proficient in science. These strands offer a new perspective on what is learned during the study of science and they embody the idea of knowledge in use: the idea that students' knowledge is not static.

For instance, the National Science Education Standards, that are a set of guidelines for the science education in primary and secondary schools in the United States [23], state that understanding science requires that an individual integrate a complex structure of many types of knowledge, including the ideas of science, relationship between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena and ways to apply them to many events.

Therefore, the four strands are [10]:

Strand 1: Understanding Scientific Explanations
To be proficient in science, students need to know, use and interpret scientific explanations of the natural world. They must understand interrelations among central scientific concepts and use them to build and critique scientific arguments. Part of this strand involves learning the facts, concepts, principles, laws, theories and models of science.

Strand 2: Generating Scientific Evidence
This strand includes things that might typically be thought of as process, but it shifts the notion to emphasise the theory and model-building aspects of science. It encompasses the knowledge and skills needed to build and refine models and explanations, design and analyse investigations and construct and defend arguments with evidence.

Strand 3: Reflecting on Scientific Knowledge
Proficient science learners understand that scientific knowledge can be revised as new evidence emerges. This strand focuses on how scientific knowledge is constructed. That is, how evidence and arguments based on that evidence are generated. It also includes students' ability to reflect on the status of their own knowledge.

Strand 4: Participating Productively in Science
Science is a social enterprise governed by a core set of values and norms for participation. Proficiency in science entails skilful participation in a scientific community in the classroom and mastery of productive ways of representing ideas, using scientific tools and interacting with peers about science. This strand puts science in motion and in social context, emphasising the importance of doing science and doing it together in groups.

Nevertheless Strand 4 is often completely overlooked by educators, yet research indicates that it is a critical component of science learning, particularly for students from populations that are under-represented in science. Students who see science as valuable and interesting tend to be good learners and participants in science [10].

Commonly, science education is seen as a straightforward process of filling students up with facts. According to this line of reasoning, if students learn enough concepts, definitions and discrete facts, they'll understand science. It is truth that learning new facts is important in science education, but is also important learning how to think about scientific explanations. Researchers group all of these kinds of changes in thinking into the general category of conceptual change. In fact, developing expertise in science means developing a rich, interconnected set of concepts—a knowledge structure—that comes closer and closer to resembling the structure of knowledge in a scientific discipline. When students understand the organising principles of science, they can learn new and related material more effectively and they are more likely to be able to apply their knowledge to new problems [10].

1.4 The Importance of Science in Pre-University Education

We now focus our attention on pre-university education, starting from preschool through high school included. This part of education in United States, Canada, Philippines and Australia is called k-12 education.

Considering especially this period, recent efforts to reform and improve the way science is taught will ensure that even those who do not pursue a career in science will benefit from the skills that can be taught in the classroom [24] [25] [26] [27] [28]. By focusing on interventions that encourage the development and practice of investigation and inference skills, science education will become increasingly relevant to the needs of all students [29].

Moreover, it has been proven that the educational process has a strong influence in shaping the future adult. Indeed, the role of education is not only to train from a scholastic point of view, but also as future citizens and adults who can act. From this point of view, the ultimate goal is to train individuals with their own personality, able to relate with society, who are able to express their personal opinions and to argue them and finally that know how stand up to comparison with people who support different ideas from their own.

1.5 Problems and Possible Solutions

To teach science well, teachers must draw on a body of knowledge that can be divided into three broad, partially overlapping, categories: knowledge of science, knowledge of how students learn science and knowledge of how to teach science effectively.

Nevertheless, many teachers, like many college-educated adults in this society [30], have only a superficial knowledge of science. Accordingly, inadequate undergraduate courses, as well as inadequate teacher education or credentialing programmes and insufficient professional development opportunities all contribute to the problem [10]. In addiction, compulsory curricula in schools must serve at least two aims: science for cultural purposes and science as a preparation for future science professionals.

Roberts [31] has coalesced these interpretations into two visions of scientific literacy:

- **Vision I** is obtained by looking inwards at the canon of orthodox natural science, that is, at the products and processes of science itself.

- **Vision II** is obtained by looking outwards, considering the character of situations with a scientific component, situations that students are likely to encounter as citizens.

Importantly Vision II subsumes Vision I, but the converse is not necessarily so. Basically, Roberts in his visions distinguishes the three domains of science (Figure1.3) [31]:

- A body of knowledge;
- A wide range of methods or processes to develop this knowledge;
- A way of thinking.

The first two domains fall within the Vision I, while the third in the Vision II. This third domain is the most abstract and least familiar of the three, it is called the nature of science or NOS. This way of thinking is what usually is acquired through informal education.
This particular way of thinking is underpinned by certain values and characteristics, those seldom-taught but very important features of working science (such as creativity, curiosity, its biases and attempts to reduce them, empiricism, its realm and limits, its levels of uncertainty, its social aspects and the reasons for its reliability) [32].
In general, the nature of science refers to key principles and ideas which provide a description of science as a way of knowing, as well as characteristics of scientific knowledge and it is an important concept in science education.

Unfortunately many of these intrinsic ideas are lost in the everyday aspects of a science classroom, resulting in students learning skewed notions about how science is conducted. The problem is that teachers do not regard the nature of science as an instructional outcome of equal status with that of traditional subject matter outcomes [33]. Usually from the perspective of formal education, science learning in the non-formal and informal sectors often appears haphazard and incoherent. Nevertheless, because it is internally rather than externally driven, this kind of learning is often long lasting and enables constructive building upon existing knowledge to take place. This kind of learning offers potentially a more holistic approach to science education, one that better integrates school, work and leisure time learning experiences and could be a more robust approach

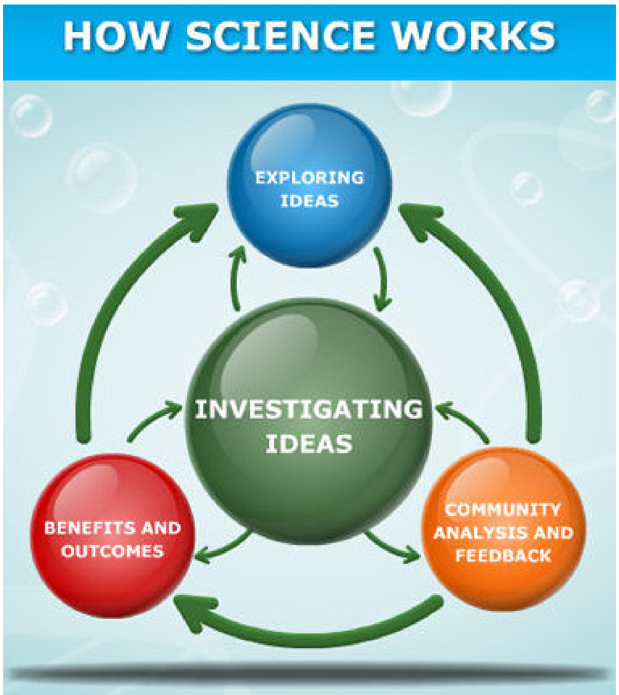

Figura 1.3: This flowchart represents the process of scientific enquiry through which we build reliable knowledge of the natural world. Most scientific ideas and research take a circuitous and iterative path, shaped by unique people and events.

to long term gains [34]. Knowing this, informal and non formal sectors could be called upon to contribute and address the current weaknesses in formal sector. In addition, Vision II courses could become influential in school science education and the formal sector will need considerable help. As a result, the informal and non-formal sectors will become fundamental to augment what the formal sector provides.

Since the words non-formal learning and informal learning are often used as synonyms, from now, when we speak about the informal sector, we consider it in its most general sense, that is including within it the non-formal sector.

Considering that a collaboration between the formal and informal education would be useful, it is necessary at this point to emphasise the complementarity between the formal and the informal education. Indeed, speaking of science as an educational tool, Jacques Barzun said: Science is, in the best and strictest sense, glorious entertainment [35].
Furthermore, there is also evidence, especially from sustained programmes but also from some short interventions, that informal experiences can radically influence a student's interest in science [36]. Without forgetting that informal science education may be vital to keep students and the general public informed of current

thinking in the field of science [37].

We can conclude that the science represented by abstract canonical concepts, of the kind found in many textbooks, tends to lack context and, because the students themselves have to provide the synthesis that makes it meaningful, it becomes unnecessarily difficult conceptually. Instead, the informal sector, less wedded to traditional texts and much more engaged in context-based science, whether in science research institutions, science museums, zoos or in the media, can and does provide for disciplinary integration and a more holistic picture of what science is really like in the world outside of school.

Ultimately, three models for the relationship between the formal and informal sectors have been developed over time:

- The formal and informal sectors are unrelated. The formal sector continues to see itself as the sole custodian of science education and continues to change at a rate defined by its governmental parameters and resources available. The informal sector sees itself as providing entertainment, using science as a vehicle, and changes at a rate determined by the commercial imperative, i.e. to get people to make use of it.

- The formal sector remains the main custodian of science education, but makes explicit use of the special capabilities of the informal sector, e.g. access to up- to-date science, opportunities for self-directed enquiries.

- The formal sector integrates the capabilities of the informal sector into its everyday working, thus creating a third space for science education.

Only recently the informal sector has been recognised as an educational provider. Therefore, the vision of the relationship between the formal and informal sectors is slowly going towards the last model, even so this process will take plenty of time and work to be completed. This means that there is an outstanding need for resources to be made available to facilitate communication and collaborative planning between informal providers and schools in an atmosphere of mutual respect.
This is the reason why the informal sector must target outreach activities to the requirements of the curriculum and ensure that those involved in providing science outreach are suitably trained and qualified to do so.
In this regard, new technologies must be used to maximum advantage. In fact, also internet and mobile technologies offer new ways to reach students and new ways of presenting science. In addition, hands-on science is in its element in this kind of environment.

Unfortunately, those responsible of formal science education have been guilty of wasting resources, time and effort – and ignoring research findings – in trying to find new ways to engage students and improve outcomes. All evidence indicates

that this effort, however laudable, has generally been far from being as successful as is needed [36]. For this reason informal science education programmes are very important, they offer resources not necessarily available in formal school settings and these resources can nurture curiosity, improve motivation and foster positive attitudes toward science.
On the other hand, the infusion of informal science education in formal teacher preparation may also provide teacher candidates with additional opportunities to experience active learning strategies such as hands-on and enquiry-based science. Furthermore, informal science education can provide teacher candidates an opportunity to begin collecting resources and adapting the materials for their future classrooms.
In fact, as Oppenheimer wrote in 1968: Explaining science and technology without props, can resemble an attempt to tell what it is like to swim without ever letting a person near the water [38].

In conclusion, the presence of this continuity in the transition from formal to informal systems, leads to the proposal of an strategy in which informal elements would be gradually incorporated by formal education, so as continuously to meet the needs of individuals and of the society [14]. Moreover, it has become important that, teaching science, teachers involve in their lessons every domains of science. For the students, learning only the theory is not enough. As result of this new approach to the science education, thanks the additional exploration of the nature of science, knowledge and skills can combine in that way of thinking we know to be very important to train not only scientists, but above all better future citizens. This is why in the future the only accepted relationship between formal and informal learning should be of collaboration and integration of capabilities.

1.6 Astronomy As a Vehicle

One of the oldest and most fascinating sciences is astronomy. It is as old as recorded history itself. Furthermore, astronomy has the power to captivate its audience and has interested the populations since the humans were on Earth. It is interesting to notice that nowadays the astronomy still holds the interest of many people. In fact, many of us have experienced a moment when, mesmerised by the beauty of a night sky, we reflected upon life, here and elsewhere. The realisation of our place in the universe is humbling, but it is also inspiring.

As we know, astronomy is a natural science that deals with the study of celestial objects (such as moons, planets, stars, nebulae and galaxies). Astronomy concerns the physical and chemical properties and the evolution of such objects and phenomena that originate outside the Earth's atmosphere (such as supernovae explosions, gamma ray bursts and cosmic background radiation) [39] [40]. In effect, analysing the meaning of the word astronomy (from the Greek words *astron*, star and -nomy from *nomos*, law or culture), we can see that literally means law of the stars (or culture of the stars depending on the translation) [41]. Consequently, as the meaning suggests, a science that explains the laws of the stars (so distant and ancient and unattainable) can easily have a special place in fantasy, imagination and interest of children, as well as adults. Indeed, with all the mysteries (resolved and unresolved), the discoveries and wonderful images that come from the Universe, it is obvious to think that astronomy is able to fascinate everyone, in one way or another. This makes astronomy a great topic to interest and to approach anyone in science, especially the children.

We have seen in section 1.4 how important is to study science during the pre-university period, not only with the aim of train future scientists but also to train better and more independent future citizens, with a different view of life and better perspectives. Surely, to achieve this purpose there are many ways, but undoubtedly astronomy education is one of the most attractive way to stimulate young people (and not only) to study sciences. In addition, astronomy is especially equipped for enquiry-based learning, a very attractive and successful learning method [42]. For this reason it is one of the subjects most commonly used in informal education. Unfortunately we cannot say the same for formal education because the teachers have not yet seen (or have intuited only in part) the potential that astronomy has.

From this point of view, astronomy is a field that has intrigued many science education researchers since the beginning of conceptual change research (e.g., Baxter, 1995; Harvard-Smithsonian Centre for Astrophysics & Schneps, 1988; Nussbaum & Novak, 1976; Vosniadou, 1991) and still draws much attention (e.g., Hannust & Kikas, 2007; Sharp & Sharp, 2007) [43].

Nevertheless, in order for astronomy to penetrate most effectively in the school curriculum, it is necessary to provide convincing support for the curriculum in a discipline to allow teachers to use it for their benefit. Moreover, the astronomy contribution to education should offer replacing subject matter in the curriculum, not offering extra material. Indeed, teachers have enough to do in limited time, thus packages should be constructed both for the teachers and for the programmes of teacher training. Finally, maximum use should be made of the fact that the same astronomy topic can be easily and attractively used over different disciplines and also serves as an ideal project for interdisciplinary teaching. Astronomical research can indeed participate in the process of school formation, increase its impact and become an important part of the learning society, as it is a model for enquiry-based science education [42].

In recent years, inspired by this vision of science education, many astronomy education and outreach programmes have been created. They help teachers and formal science education in general to consider and to take advantage of the unique and wonderful perspective that astronomy has to offer. In fact, thanks to Astronomy and to the power it has to captivate his audience, these programmes try to stimulate and to speed up the process of fusion between formal and informal science education. The result of this process is what we have seen to be the fundamental objective of science education: the development of skills and values that will help future generations of adults to create a better future for themselves.

Conclusions

As we have seen in this first chapter, science education is important in pre-university education and it must be developed in every aspect.

Primarily, a change in the way of seeing science and science education is in progress. The researchers call this change, conceptual change. In fact, we cannot anymore consider science education only from the point of view of the content. In fact it is necessary to consider science education as a single body composed of content, process and way of thinking.
In addition, we must take into account all types of learning that characterise our education: formal, non-formal and informal. Therefore we can not consider the various types of education as separate, self-contained and not interpenetrated units, instead we must consider them complementary and indispensable to education. Thanks to this complementarity and to the conceptual change we develop the knowledge, the skills and that particular way of thinking that are essential to train adults able to build a better future.
Moreover, a way to speed up this process and to achieve those goals is to render science education more attractive and exciting. This means exploit those subjects that for their characteristics are best suited to become basic in science education.

In this regard, astronomy is considered one of the subjects most suitable and useful, not just because it is especially equipped for enquiry-based learning and it is ideal for interdisciplinary teaching, but also because it is one of the subjects most fascinating and inspiring.

Finally, we suggest to encourage this general transformation of science education by giving more space to the astronomy education and outreach programmes. There are many of these programmes around the world, some of them are local, others are international. We mention some of these programmes as example: the outreach section of European Space Agency - ESA [1] and National Aeronautics and Space Administration - NASA [2], Hands On Universe - HOU, Global and European [3], Astronomical Society of the Pacific - ASP [4], Universe Awareness - UNAWE, Global and European [5] and several other.

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[1] http://www.esa.int/Education and http://www.esa.int/esaKIDSen/

[2] http://www.nasa.gov/audience/foreducators/index.html and http://www.nasa.gov/audience/forstudents/index.html

[3] http://www.globalhou.net/ and http://www.euhou.net/ and http://www.handsonuniverse.org/index.html

[4] http://astrosociety.org/

[5] http://www.unawe.org/ or http://www.eu-unawe.org/

In the next chapter we focus on one of these astronomy education and outreach programmes: Universe Awareness - UNAWE.

Capitolo 2

The Case of Universe Awareness

In this chapter we discuss the case of *Universe Awareness* or simply UNAWE. Firstly, we introduce what UNAWE is and how it was born. Secondly, we analyse who is UNAWE' s target audience and why. Thirdly, we present what are the different social environments in which UNAWE is active and how the goals are tailored for every different environment. Furthermore, we explain in which educational sectors UNAWE works and how the educational goals are reached.

2.1 How and Why UNAWE Was Born

This section is for the most part extracted from the articles of *Ödman-Govender & kelleghan 2011* [44] and *Arisa et al. 2013* [45] and from the UNAWE website [46].

Universe Awareness (UNAWE) is a global astronomy education and outreach programme. Founded by Professor George Miley from Leiden University (Leiden, The Netherlands), the project UNAWE was born in 2005, with the intention that children, of every country and every economical and social condition, can be in touch with astronomy. As we have seen in the previous chapter (section 1.6), the idea of this project comes from the fact that astronomy embodies a unique combination of scientific and cultural aspects.
Indeed, our awe-inspiring Universe captures the imagination of children from all corners of the world, making it a great stepping stone to introduce youngsters to science and technology, to convey the beauty of our cosmos, the excitement of new astronomical discoveries and the pleasure of learning fundamental knowledge about the Universe. Moreover, many scientists can trace their interest in science to a moment as a young child, when they were first introduced to the wonders of science.

It is necessary highlight that considering the vastness and beauty of the Universe and our place within it introduces children to the fun of science and provides a special perspective that can help broaden the mind and stimulate a sense of global citizenship and tolerance. In fact, for this reason UNAWE focuses its attention especially on disadvantaged communities. As Dr Carolina Ödman, UNAWE project manager in 2010, said: Wonderment of the night sky has been a source of inspiration throughout the history of humankind. Astronomy has deep roots in most civilisations and as such can help us understand our identity and diversity.

It is important to note that UNAWE is the first large-scale attempt to use astronomy as a tool to inspire and educate children and it is endorsed by UNESCO and the International Astronomical Union (IAU) [1].

As we know, the idea of setting up this astronomy programme to educate and inspire young children, especially those from underprivileged backgrounds, was firstly explored by Professor George Miley in 2004. He was inspired by the smiling faces of children, who sat captivated as they listened to him tell stories about our Universe. Indeed, like any devoted parent, Professor George Miley took a keen interest in his children's education and volunteered to give talks about astronomy in their primary school. Miley says: It was marvellous to see how very young children became excited when I showed them Hubble pictures and told them about the strange objects in our Universe.

In fact, the opportunity to start UNAWE project presented itself when Professor Miley had been awarded an Academy Professorship by the Royal Netherlands Academy of Arts and Sciences and decided to use part of the associated funding to explore the feasibility of setting up such a programme. With considerable support and encouragement from Claus Madsen at European Southern Observatory (ESO), the European Organisation for Astronomical Research in the Southern Hemisphere, a successful workshop was held in Germany and it was agreed that the programme was worth pursuing. As Claus Madsen from ESO says Astronomy involves natural sciences and technology and has strong links to philosophy, the arts and human development. Because of its multifaceted nature, astronomy is a unique discipline for exciting young children and imbuing them with an appreciation of both science and culture. Finally, in 2006, thanks to a grant provided by the Netherlands Minister of Education Culture and Science, the UNAWE International Office was founded at Leiden Observatory (Leiden University).
Afterwards, in 2011, a grant of 1.9 million Euros was awarded by the European Union's Seventh Framework Programme to fund a project called European Universe Awareness (EU-UNAWE), which builds on the work of Universe Awareness (UNAWE). At the moment EU-UNAWE is the European branch of the global UNAWE programme and with this grant, EU-UNAWE is now being further de-

[1] The IAU is an international astronomical organisation of about 10859 professional astronomers from 93 countries. Its mission is to promote and safeguard the science of astronomy in all its aspects through international cooperation. The IAU also serves as the internationally recognised authority for assigning designations to celestial bodies and surface features on them

veloped in six selected countries: The Netherlands [2], Germany [3], Spain [4], Italy [5], the United Kingdom [6] and South Africa [7].

Although UNAWE was founded only eight years ago, it has grown a lot, especially during 2009, International Year of Astronomy. It is already active in more than 50 countries and comprises a global network of more than 800 astronomers, teachers, and other educators, but its ambition is to have an active UNAWE programme in every country in the world by 2020 [8]. The international network provides a platform for sharing ideas, best practices and resources between educators from around the world. The network is also used to run ambitious global projects, with the aim of broadening children's horizons beyond their local area and to show them that they are part of a global community. For instance, in 2009, the IAU coordinated the International Year of Astronomy 2009 (IYA2009), the largest science education and public outreach event in history, reaching hundreds of millions of people in 148 countries. During this event, indeed, UNAWE became a cornerstone project of this successful United Nations (UN)-ratified IAU/UNESCO International Year of Astronomy.

2.1.1 International Projects

After the successful experience of IYA2009, UNAWE has been involved and is now an integral part of the IAU Strategic Plan 2010-2020, which is called Astronomy for the Developing World. This is an ambitious blueprint that aims to use astronomy to foster education and provide skills and competencies in science and technology throughout the world, particularly in developing countries.

The IAU Strategic Plan 2010-2020 Astronomy for the Developing World-Building from IYA2009 was adopted at the IAU General Assembly in August 2009 and is now a crucial part of the IAU's mission. The plan includes a vision, specific goals for the decade, a strategy for attaining them and a detailed blueprint for their implementation [9]. The plan discusses at length the many reasons why astronomy can play a unique role in furthering education and capacity building throughout the world (Figure 2.1).

One of the most important social functions of modern astronomy is as a tool for education in the broadest sense. Because it is one of the most approachable of sciences that consistently fascinates young people, as we have seen, astronomy is an excellent vehicle for introducing science and technology to children. In fact,

[2] Leiden University
[3] Heidelberg University
[4] Universitat Politècnica De Catalunya
[5] INAF - Arcetri Observatory
[6] Armagh Observatory
[7] South African Astronomical Observatory - SAAO
[8] Ambassador Programme is the project for the expansion of UNAWE action in every country
[9] http://iau.org/static/education/strategicplan_2010-2020.pdf

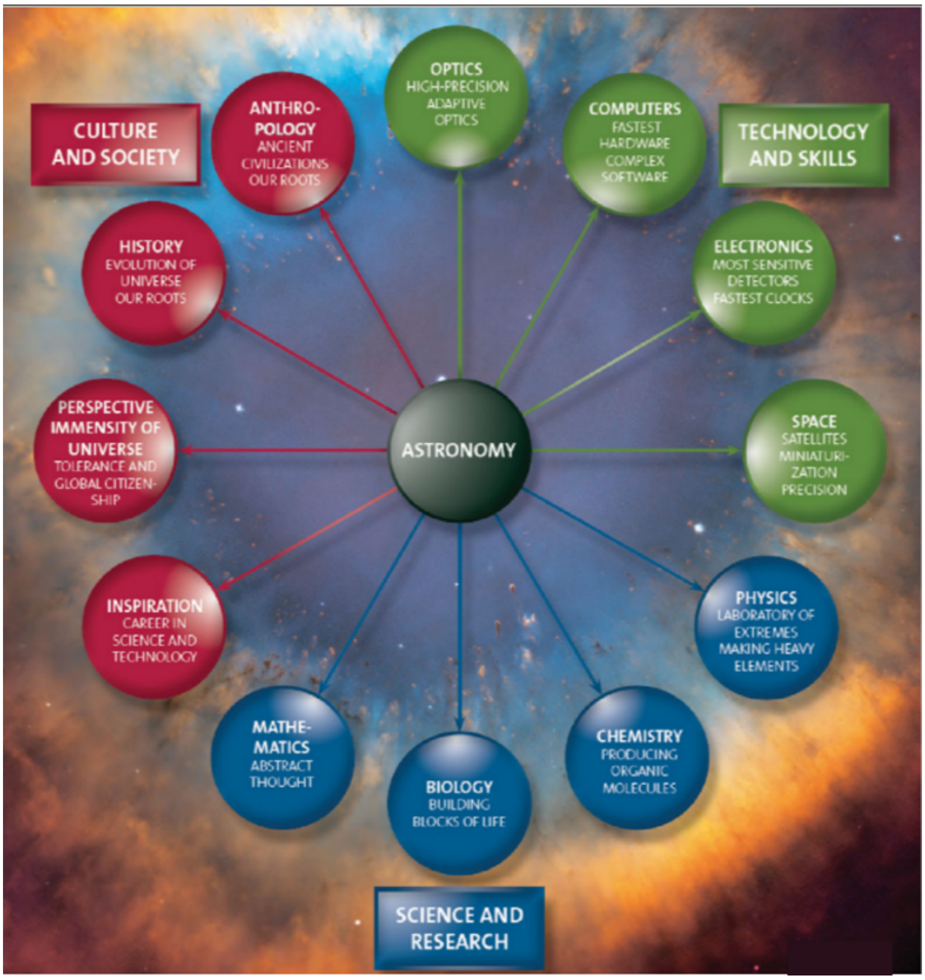


Figura 2.1: Reproduction of cover of the IAU Strategic Plan document, illustrating why astronomy is an excellent vehicle for capacity building and international developmeng [47].

the accessibility of the sky, the beauty of cosmic objects and the immensity of the Universe are inspirational and provide a perspective that encourages internationalism and tolerance. Furthermore, the excitement of astronomy has stimulated large numbers of young people to choose a career in science and technology, thereby contributing to the knowledge economy of many countries.

In summary, because astronomy combines science and technology with inspiration and excitement, it can play a unique role in facilitating education and capacity building and in furthering sustainable development throughout the world [48].

Moreover, in accordance with the IYA aims, an important part of the strategy of the plan is to further the UN Millennium Goals in all of the astronomy for development activities. The United Nations' Millennium Development Goals form a global action plan agreed upon by each and every country for developing a poverty-free world with a healthy population and equal rights. All 193 United Nations member states and at least 23 international organisations have agreed to achieve these goals by the year 2015. The goals are [10] [49]:

- eradicating extreme poverty and hunger
- achieving universal primary education
- promoting gender equality and empowering women
- reducing child mortality rates
- improving maternal health
- combating HIV/AIDS, malaria, and other diseases
- ensuring environmental sustainability
- developing a global partnership for development.

Particular attention is given to promoting gender equality and empowering women (Millennium Goal 3), in helping to achieve universal primary education (Millennium Goal 2) and to develop a global partnership for development (Millennium Goal 8).

It is important to emphasise that using astronomy to stimulate quality and inspiring education for very young disadvantaged children has been an important goal of the Universe Awareness programme since its inception [50]. For this reason UNAWE can be an invaluable resource helping to provide the key to achieving all eight millennium development goals, overcoming generations of inequality and poverty, and unlocking national prosperity.

In addition to all this, UNAWE has become a member of the international Education for All initiative, a movement aiming to ensure a quality education for every child, youth and adult around the world. The current situation is that over 70 million children around the world are being denied education with millions more receiving just the minimum. Education for All, led by the United Nations Special Envoy on Global Education, plans to change this situation by ensuring a place in school for every child in every country by 2015, as we have seen this is the second goal of the UN Millennium Development Goals. Moreover, providing basic education around the world is the most important step to fulfilling all the Millennium Development Goals by 2015. Indeed, indirectly good education provides the key to overcoming generations of poverty and unlocking national prosperity. Education is a human right with immense power to transform. On its

[10] http://www.unawe.org/about/MDG/

foundation rest the cornerstones of freedom, democracy and sustainable human development. – Kofi Annan, seventh secretary-general of the United Nations, 2001 Nobel Peace Prize [51].

Ultimately UNAWE wants to achieve the commendable goal of provide equal opportunities to children in an international context to develop their talents and to arouse their curiosity. With its combination of social, educational and scientific goals, UNAWE can play a unique role in furthering education and development.

We conclude this section with a citation that seems an appropriate symbol for UNAWE project. Einstein once said [52]: I have no special talents. I am only passionately curious.

We will now analyse in the next sections why UNAWE has decided to focus on young children and especially those who live in disadvantaged backgrounds.

2.1.2 Young Children Matter

It is important to highlight that the UNAWE resources are mainly tailored to children aged 4 to 10. The choice of this age group is not random but supported by new theoretical ideas and empirical researches, as for example the researches conducted at the University of East Anglia in the UK [53] [54] , at the University of California - Berkeley [55], at the University of Pennsylvania [56] and at the University of Tel Aviv [57]. Unfortunately for science education, all of these new researches, that greatly support UNAWE' s work, have been developed only recently.

Instead, the previous theories were totally the opposite and, obviously, they affected every aspect of education since the 20s to the 90s. Indeed, thirty years ago, the idea that young children think like scientists would have seemed absurd. J. Piaget, great developmental psychologist since the 20s, claimed that preschoolers' thinking was just the opposite of scientific thinking. Preschoolers were irrational, illogical and limited to the here and now [58]. During the 80s and 90s, other developmental psychologists have hypothesised that young children from naïve theories about the world around them based on what they witness. Proponents of this hypothesis, such as S. Vosniadou and W. Brewer, said that counter-intuitive scientific theories are difficult for young children to accept and that the role of educators is to challenge these naïve theories. They argued that scientific explanations about how the Universe works can only be introduced at a later stage of a child's education (around 10 years old), once they become aware that their naïve theories are wrong [59] [60].

All of these claims have turned out to be wrong. In fact, in the past 10 years, new researches have begun to show that children's learning mechanisms do indeed resemble the basic inductive processes of science. To a striking extent, children use data to formulate and test hypotheses and theories in much the same way that scientists do. Of course, formal scientific thinking involves a level of self-conscious reflection, including reflection on the very process of science itself. This reflection is not present in very young children: the preschoolers see probabilistic evidence and revise hypotheses, but they don't necessarily know that this is what they are doing. Nonetheless, we should be able to exploit the fact that very young children are natural scientists in action to help them understand the principles of formal science [55].

One of the proponents of these new theories is Dr G. Panagiotaki, a lecturer in Developmental Psychology at the University of East Anglia in the UK. She says that children as young as four years old are able to understand basic scientific ideas. Even though children are often not able to explain their ideas in great detail, scientific information and facts can be present from early on. And children benefit enormously for appropriate instruction and educational activities aimed at teaching them basic facts [61]. There are also other researches that support this conclusion, for instance Professor of psychology A. Gopnik, at the University of California, Berkeley, has found that very young children's learning and thinking are strikingly similar to much learning and thinking in science, thus young children actually think in the way scientists do, testing hypotheses against data and making causal inferences. They learn from statistics and informal experimentation, and from watching and listening to others. Additionally, Gopnik's research shows that encouraging play and letting children search for explanations themselves, rather than solely explain things, incites scientific thinking [55]. Also the neuroscientist M. Farah of the University of Pennsylvania reaches the same conclusion by looking at the development of children's brains. In her research, she shows that the 4-year old brain is extremely vulnerable to its environment. If children of this age grow up in an educational environment, including books and educational toys, their brain is affected in a significantly positive way. The researchers conclude that the thickness of two regions in the cortex is enhanced by such stimulating surroundings. At age 8, the impact on the brain is already much smaller [56]. Moreover, the research of N. Liberman, professor in social psychology at Tel Aviv University, shows that learning about distant objects promotes more abstract thought. When visualising proximal objects, individuals tend to use concrete and detailed images, while picturing an object in a more abstract, de-contextualised way when thinking about distal objects – either temporally distant (in the far future), hypothetically distant (unlikely), or spatially distant (actually far away). She confirms that psychological distance promotes abstract thought, which, in turn, promotes creativity [57].

All of these researches show that an early age is a perfect time for children to get in touch with science for the first time. The researchers have discovered that a child's early years are widely regarded to be the most important for development and education. Indeed at this age, children are developing their cultural landscape and value systems, which serve as references as they grow and learn [46]. Moreover, at these ages children can readily appreciate and enjoy the beauty of astronomical objects and can learn to develop a feeling for the vastness of the

Universe. The sky and the Universe can excite young children and stimulate their imagination [47].

In addition to all of this, another reason why it is important to stimulate the minds of young children is that the life cycle skill formation is a dynamic process in which early inputs strongly affect the productivity of later inputs. In fact, from decades of independent research in economics, neuroscience, and developmental psychology, four core concepts have emerged in favour of this thesis [62]. First, the architecture of the brain and the process of skill formation are influenced by an interaction between genetics and individual experience. Second, the mastery of skills that are essential for economic success and the development of their underlying neural pathways follow hierarchical rules. Later attainments are build on foundations that are laid down earlier. Third, cognitive, linguistic, social, and emotional competencies are interdependent; all are shaped powerfully by the experiences of the developing child; and all contribute to success in the society at large. Fourth, although adaptation continues throughout life, human abilities are formed in a predictable sequence of sensitive periods, during which the development of specific neural circuits and the behaviours they mediate are more plastic and therefore optimally receptive to environmental influences [63].

Ultimately, every aspect of early human development is affected by the environments and experiences that are encountered in a cumulative fashion, beginning in the prenatal period and extending throughout the early childhood years [64]. This principle stems from two characteristics that are intrinsic to the nature of learning [65]:

- early learning confers value on acquired skills, which leads to self-reinforcing motivation to learn more

- early mastery of a range of cognitive, social and emotional competencies makes learning at later ages more efficient and therefore easier and more likely to continue.

Indeed, the advantages gained from effective early interventions are sustained best when they are followed by continued high-quality learning experiences. The technology of skill formation shows that the returns on school investment and post-school investment are higher for persons with higher ability, where ability is formed in the early years [63].

In conclusion, it is no coincidence that UNAWE works mainly with children aged 4 to 10. In fact, UNAWE intervenes in this crucial age of development, stimulating minds with scientific arguments and also taking advantage of astronomy and of its peculiar characteristics. UNAWE acts at 360 degrees on all important aspects of education which, as we have seen, have emerged from the latest researches in this field.

2.1.3 Privileged and Underprivileged

We have seen in section 2.1 that UNAWE resources are available for children of every country and every economical and social condition. Therefore UNAWE efforts are directed to privileged and underprivileged communities around the world, but not all goals may be the same in these two environments. In fact, we know that thanks to UNAWE's work, children approach to science and technology with all the benefits that result there-from and, despite UNAWE aims to captivate and to inspire every children with astronomy, the ultimate goal in the two cases is different.

Surely, when all these children will be adults, they will be able to create a better future and they will have developed important capacities and skills, as we have seen in chapter 1 and in the previous section. The basic difference lies in the fact that while in privileged communities UNAWE aims to inspire children to pursue one day a career in science, in underprivileged communities UNAWE aspires above all to enable them to get out of the disadvantaged situation they are in, so that they can also improve the situation of their country. In the long term, UNAWE aims to help produce the next generation of engineers and scientists and to make children from underprivileged areas realise that they are part of a much larger global community.

This is an important point, because 200 million children in the developing world are not fulfilling their potential for development [66]. Indeed, because of poverty, under-nutrition, micro-nutrient deficiencies, and learning environments that do not provide enough responsive stimulation and nurturance, children are developing more slowly, or failing to develop critical thinking and learning skills. Furthermore, this limitation in early development contributes to late school entry, poor school performance and, ultimately, limitations for success later in life. Therefore, for disadvantaged children, this initial deficit has a multiple effect: children raised in poverty complete far less education than middle class children, due in part to their lowered ability to learn in school. Basically, an holistic approach to children's development is needed to reduce and eliminate this chain of problems that affects disadvantaged children. Moreover, as we have seen, the most effective interventions to improve human development, to increase the chances of all children for success and break the cycle of poverty occur in children's earliest years [66].

It is clear at this point that Universal Primary Education (UPE) plays a key role in achieving of all the eight international Millennium Development Goals (section 2.1.1). More specifically, UPE has to ensure that by 2015, children everywhere, boys and girls alike will be able to complete a full course of primary schooling. Towards this goal many progresses have been made in the past decade, though barriers still remain [67]. Moreover, this goal is fundamental because, as demonstrate by a study conducted by the UNESCO International Institute for Educational Planning, stronger capacities in educational planning and management may have an important spill-over effect on the system as a whole [68].

Indeed, the focus of many international organisations has been on educational planning and management so that stronger capacities in these areas lead to important improvements in the education system. Much of their work aims to strengthen national capacities through training, technical advice, exchange of experiences, research and policy advice. Therefore we can deduce that capacity development is a fundamental action, without which countries will not achieve their development goals. Without capacity, there is no development [68].

That is why UNAWE considers important to focus mainly on underprivileged environments. UNAWE helps these communities the opportunity to come out of the disadvantaged situation and to hope for a concrete development and future well-being.

2.2 The Right Strategy

In light of what we have seen until now, to guarantee a better future for every child around the world, the best strategy to follow is to intervene with science in the education of young children, especially those of underprivileged communities. Utilising the most suitable of the sciences to this role, the astronomy, this is exactly what UNAWE does.

Indeed, many charitable organisations have highlighted the importance of educating young children from disadvantaged backgrounds. UNICEF' s Programming Experiences in Early Child Development 2006 report, for example, states that educating disadvantaged children in their earliest years offers the best opportunity to give them an equal start in life [46]. However, early childhood care and education is often the responsibility of parents, and many families in underprivileged environment are not in a position to offer as much to their children as wealthier parents. I regarded disadvantaged children as the most important group for UNAWE to target, because they are least likely to be exposed to the excitement of astronomy, says Miley, UNAWE' s chairman.

Essentially, environments that do not stimulate the young children and fail to cultivate skills at early ages place them at an early disadvantage. Moreover, disadvantaged early environments are powerful predictors of adult failure on a number of social and economic measures. Therefore, many major economic and social problems can be traced to low levels of skill and ability in the population [63]. Ultimately, investing in disadvantaged young children promotes fairness and social justice and at the same time promotes productivity in the economy and in society at large, nonetheless, this is a rare public policy initiative [63].

In support of this thesis there are many examples of projects and studies conducted in Europe and America, we name a few: the Effective Preschool Provision Project in Northern Ireland (EPPNI) [69], the large-scale expansion of preschool undertaken in France [70], the High Scope Perry Preschool Programme in Michigan (HSPP) [71] and many others. They argue that invest in young and disadvantaged children is the right strategy to pursue to produce more successful adults. Indeed, they concluded that widening access to preschool can improve performance and equity by reducing socio-economic disparities (Figure 2.2) [72]. In fact, high preschool attendance is associated with increased qualifications, employment, and earnings up to age 33 [73]. Therefore, preschool attendance appear to reduce socio-economic inequalities, as children from less advantaged backgrounds benefited more than those from more advantaged backgrounds [70] [69].

The High/Scope Perry Preschool Programme (HSPP) is a much-cited example for what investing in the education of young, disadvantaged children can achieve in the long-term. Beginning in the 1960's, HSPP randomly divided 123 disadvantaged African-American children aged between 3 to 4 years old into a group that received a pre-school programme and a control group that received no intervention. HSPP maintained contact with the study' s participants every year until the age of 11, and then conducted follow-up interviews at ages 14, 15, 19, 27 and 40 [63]. In 2005, a study of 97% of the participants (then aged 40) revealed that those who had taken part in the pre-school programme achieved greater success in life than the control group, such as higher rates of graduation, better paid jobs and fewer criminal records [71]. This report substantially bolsters the case for early interventions in disadvantaged populations economist J. Heckman, from the University of Chicago, said in a HSPP press release. The economic benefits of the Perry Programme are substantial. Rates of return, the increments in earnings and other outcomes, per year for each dollar invested in the child, are 15 to 17% [74].

We can not ignore the results reported from this and others similar cases. They are a clear example of how it is possible significantly help disadvantaged communities with only a small investment in the education of young children. Therefore the grounds that should lead society to invest in disadvantaged young children are fairness, social justice and economic efficiency. Nevertheless economic efficiency is more powerful than the equity argument, this because the gains from making such investments can be quantified and they are substantial. There are many reasons why investing in disadvantaged young children has a high economic return. For instance, early interventions for disadvantaged children promote schooling, raise the quality of the workforce, enhance the productivity of schools and reduce crime, teenage pregnancy and welfare dependency. Therefore, they raise earnings and promote social attachment. In addition, it is possible to avoid the equity-efficiency trade-off [11], that plagues so many policies, giving the right importance to skills in the modern economy and to the dynamic nature of the skill acquisition process.

[11] Within this equity and efficiency trade-off, equity refers to the economy's financial capital, while efficiency refers to the future efficiency in the production of goods and services. This theory asserts that, in order for a nation to become wealthier, it must save its equity. However, these additional savings will hurt the development of more efficient production in the future [?].

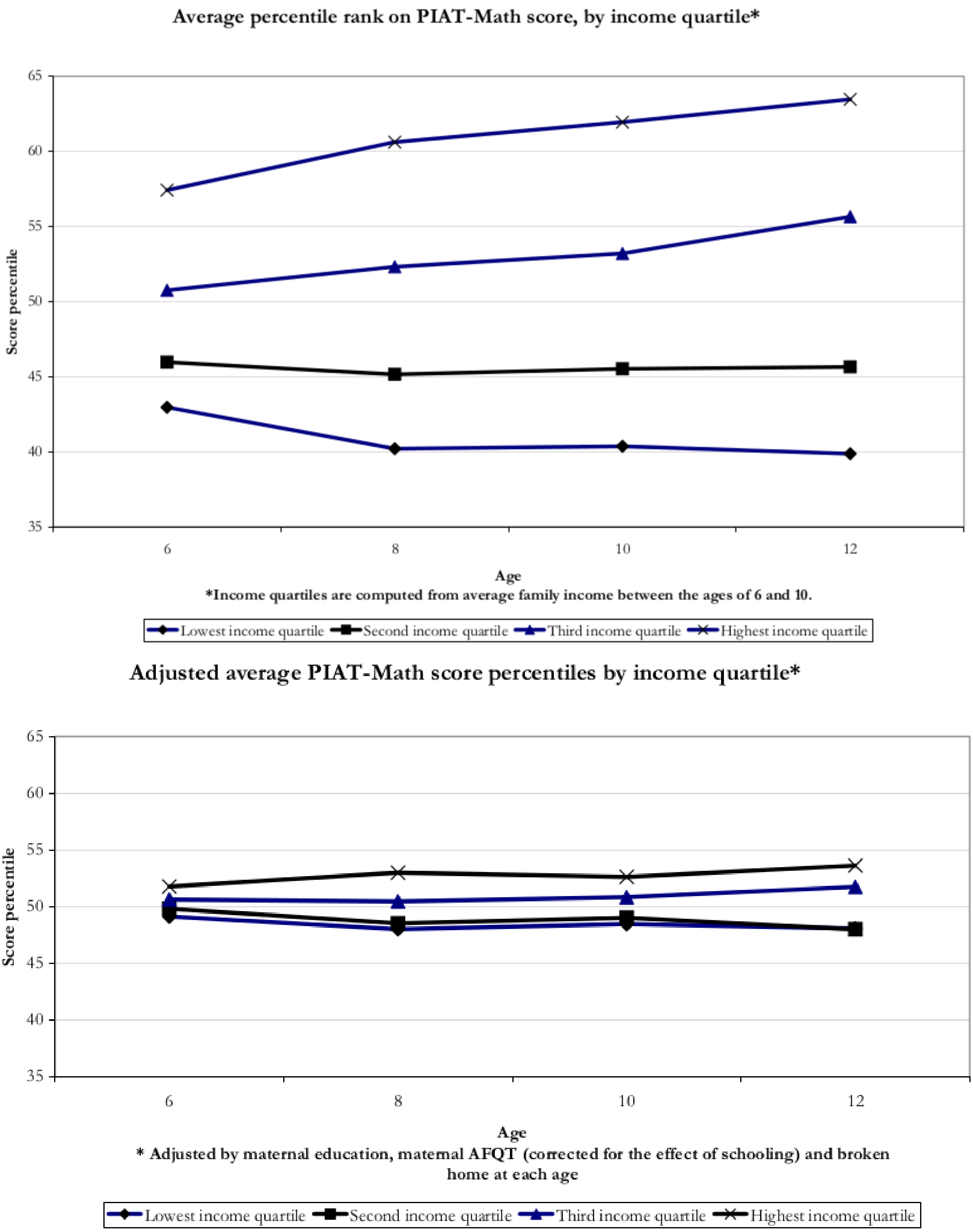


Figura 2.2: Average percentile rank on Pea-body Individual Achievement Test–Math score by age and income quartile, without (above) and with (below) maternal education. Income quartiles are computed from average family income between the ages of 6 and 10 (Adapted from [65] with permission from MIT Press).

In fact, a large body of research in social science, psychology and neuroscience shows that skill begets skill, learning begets learning and motivation begets motivation. Namely, early skill makes later skill acquisition easier, instead lack of early skill and motivation begets lack of future skill and motivation. Using a metaphor, the earlier the seed is planted and watered, the faster and larger it grows. Otherwise, if the seed is not planted and watered early, it will produce a stunted adult [75]. Indeed, early interventions have much higher economic returns than other later interventions such as reduced pupil-teacher ratios,public job training, convict rehabilitation programmes, tuition subsidies or expenditure on police (Figure 2.3). Therefore, these early interventions have high benefit-

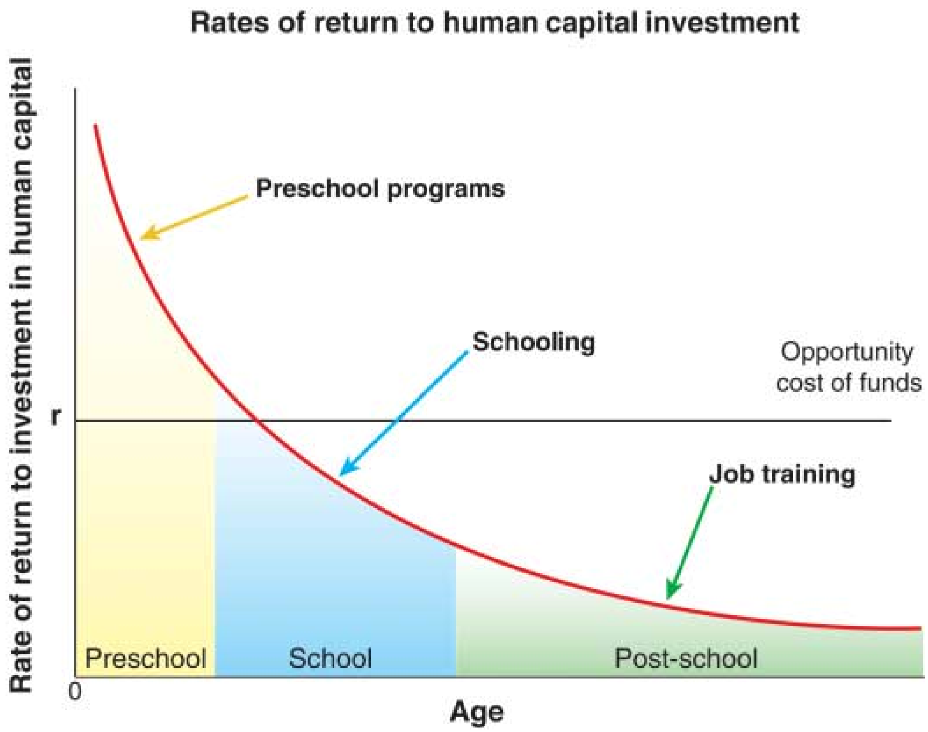


Figura 2.3: Rates of return to human capital investment in disadvantaged children. The declining figure plots the payout per year per dollar invested in human capital programmes at different stages of the life cycle for the marginal participant at current levels of spending. The opportunity cost of funds (r) is the payout per year if the dollar is invested in financial assets (e.g., passbook savings) instead. An optimal investment programme from the point of view of economic efficiency equates returns across all stages of the life cycle to the opportunity cost. The figure shows that, at current levels of funding, we over-invest in most schooling and post-schooling programmes and under-invest in preschool programmes for disadvantaged persons (Adapted from [65] with permission from MIT Press).

cost ratios and rates of return. On the contrary, re-mediation for impoverished early environments becomes progressively more costly the later it is attempted. This means that if we wait too long to compensate for the deprived early environments, it becomes economically inefficient to invest in the skills of the disadvantaged [63] [75]. In conclusion, this shows that investing in education in a child's earliest years is not only worthwhile, but also the best time in absolute to intervene [63].

This shows that young children in developing countries, living in less supportive environments, can greatly benefit from UNAWE' s programme. They learn about the universe, but the side effect is: by being axposed to UNAWE educational material, they develop important skills. More importantly, all this will increase the potential to contribute to society in the future.

2.3 What UNAWE Does

The UNAWE Project is involved in many different activities and uses astronomy to further every type of science education that we discussed in section 1.2. UNAWE contributes to the formal sector through the teacher training and the non-formal and informal sectors through the educational resources development.

The choice of teacher training is obvious, it is necessary to take action on those who officially bestows education, to improve this sector from the base in every country. The last choice is instead supported by many reasons and perspectives. First of all, there is evidence that non-formal education assists in the decision-making of educational and development funding agencies on both a national and international level [14]. This is an important point because it involves the survival and prosperity of projects like UNAWE. Non-formal education has this crucial role because it promises to maintain a positive benefit/cost analysis in order to provide effective and targeted results with the highest possible monetary efficiency. Moreover, it promises to be a more effective approach to relating education to national development. Indeed, many researches in this field say that non-formal and informal education offer a more eclectic, multidisciplinary approach to the problem of development in a country. These approaches offer education that is functional and practical, i.e., related to the life-needs of the people and promise to produce short-term effects as well as long-term achievements [36] [18] [14]. It cannot be denied that with basis on the varied instances of their successful implementation, as well as on their ethical and technical foundations, non-formal and informal educations offer an answer to the quest of alternatives to solve the educational problems we have, particularly in developing countries [14].

It is also necessary to emphasise that educational projects like UNAWE have a great commitment to seek innovative means in every educational sectors. This commitment is fundamental to achieve the goals. Consequently, UNAWE, as astronomy education and outreach programme, has many different activities and objectives. For instance, we have already seen some of the big international project which involve UNAWE, as the IAU Strategic Plan 2010-2020 and others in section 2.1.1. Nevertheless, in every country in which UNAWE is active (Figure 2.4) with a national programme, it is also locally involved in public outreach, especially with children and families. In addition to all this, there are the main activities of the UNAWE project. UNAWE consists mainly of three component:

- Teacher training;
- Development of relevant educational material;
- An international network.

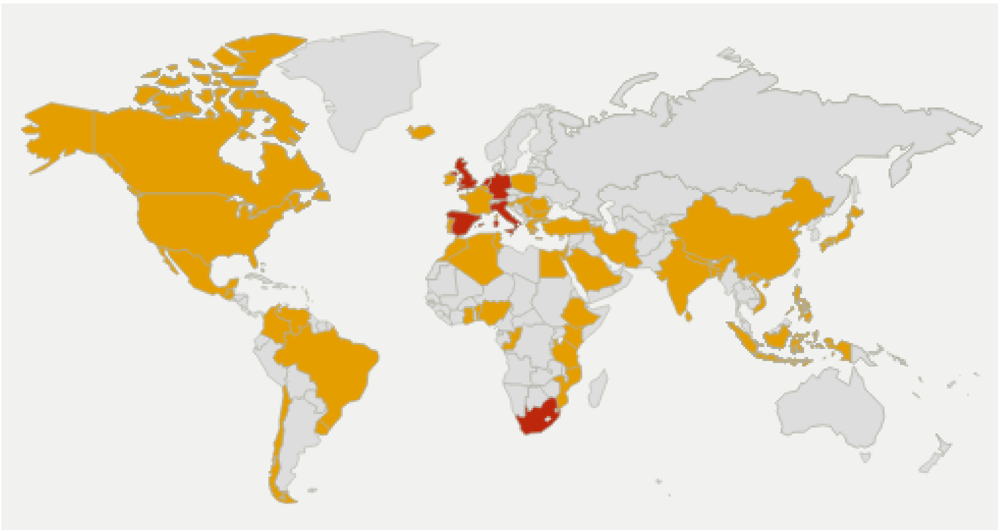


Figura 2.4: The countries that belong to the EU-UNAWE Consortium are six (red) and UNAWE currently has other 58 member countries (yellow). Each member country has a national programme, which coordinates its UNAWE activities and acts as a point of contact for people to find out what is happening in their local area.

We now go to see in more detail which are the UNAWE' s activities and what are its final goals.

2.3.1 Public Outreach

Astronomy is the most approachable of all sciences for the general public. Everybody can gaze at the sky and appreciate its beauty. The evocative images produced by modern telescopes fascinate, whereas stories about exotic cosmic objects and the evolution and origin of our Universe can inspire, entertain and stretch the imagination. Information about the state of the Universe in the distant past has deep implications about the roots and future of our species [47].

In order to approach the general public to all this, UNAWE organise events and workshops, for example at the local community centre or library, that involve especially families and children. These sessions, thanks to astronomy, provide an ideal introduction for children and teenagers to the creative excitement of the exact sciences and frequently stimulate students to embark on a scientific career. Moreover, the adventure of astronomy is a popular ingredient of adult education programme [47].

2.3.2 Teacher Training

Teacher training at primary level is a crucial element of national development of every country. In addiction, outreach to teachers in the developing world will involve the preparation and translation of materials, the provision of training courses and harnessing global technological resources in the service of education [47].

For these reasons, provide training activities for teachers and other educators of young children is a particularly important goal of UNAWE. To achieve this goal, UNAWE organise teacher-training courses and workshops. Indeed, UNAWE aims to give teachers the confidence to introduce astronomy and other science topics in the classroom, and to create innovative methods for engaging young children in astronomy [45]. For example, one of the most innovative proposals is the DUO intern-ships, in which an astronomy student and a student teacher will team up to teach at a primary school.

In fact, it is important put teacher development in the spotlight in the upcoming years because the teacher is the key to achieving a high quality of education [46].

2.3.3 Educational Material

Learning should be exciting and fun − and this is never truer than when dealing with young children. For this reason UNAWE encourages learning through play and hands-on activities. The vast set of UNAWE educational materials includes beautifully illustrated hands-on and board games, books, posters, magazine and educational activities.

Moreover, UNAWE is currently developing new resources, for example Universe in a Box, a low-cost activity kit developed to assist teachers and educators in bringing astronomy to the classroom and outreach programmes. In this way the resources can be also used in connection with the curriculum in the formal education, thus acquiring a broader educational purpose. Another examples is the astronomy news service for children, called Space Scoop, which is produced in partnership with the European Southern Observatory. The idea behind Space Scoop is to share with children the excitement that the latest scientific discoveries bring, and to demonstrate that there is still much to learn about the Universe, research that they could contribute to in the future [45].

All UNAWE educational resources, generously contributed by a network of volunteers, have been collected and published. Many UNAWE members have contributed to translations, which are featured on the site [12]. Furthermore, all the educational material will be early collected in a new database and made available through an online platform. In addition, the quality control of the educational resources, before publication, comes through an automatic peer adoption process. Namely that the resources are checked for scientific accuracy by qualified astronomers before they are posted online. We deepen this latter part in the next chapters.

2.3.4 International Network

Crowd-sourced efforts and online educational resources are able to multiply the impact of astronomy outreach and education [48]. This allows educators and communicators from around the world to discuss experiences and successful teaching methods, which translates to a better quality of education for students and the public alike.

Effectively, UNAWE is creating a global network that allows teachers, educators and parents to share knowledge, ideas, materials and resources. The network allows UNAWE to run exciting international projects, reaching and introducing teachers, students and the general public from all backgrounds and continents. This means providing more access to modern technology and internet to teachers and students in the poorest countries and most remote regions [46]. Nevertheless, while technology today makes everything easier, as directly connecting people from around the world through the click of a button, UNAWE also posts educational resources such as posters, books and hands-on activities. This is a way to help less developed regions, where few have a computer and the connections are shoddy.

Finally, the international network ensures that UNAWE is up to date with the fast-paced field of astronomy, that it is providing the most relevant information in an effective and engaging way, and that all areas of the world have access to necessary equipment for providing good education [46].

Conclusions

There are evidences that in many countries, an increase in scientific wealth has been linked with an increase in economic wealth, a decrease in poverty and even a more stable government [46]. Therefore, astronomy is an outstanding tool for furthering sustainable international development around the globe and for provide also basic education to every child and adult, that is the first and most important step towards the global development. Astronomy is also a particularly important tool in stimulating human capacity building and education at all levels. Indeed, good education is the foundation for the future of students, but also for labour market and economy. In addition, astronomy can be effective in stimulating also

[12] www.unawe.org

technological capacity building. In fact, in the past, it has driven the development of several new cutting-edge technologies that are now being used in everyday life, such as wireless Internet, GPS navigation and medical X-ray imaging [46].

Ultimately, the challenge, and at the same time responsibility, for astronomy research is to help attracting young people to science and technology as a solid part of the existing educational system. Moreover, the implementation of astrophysically based tools and packages into the curriculum is possible because its research shows strong characteristics of enquiry-based science education [42].

Do not underestimate that, as programme that aspires to motivate very young children, especially those from underprivileged backgrounds, with the grandeur of the Universe, UNAWE is extremely cost-effective and can provide many benefits to society for a relatively small fraction of the expenditure on astronomical and space research [46]. Despite this cost effectiveness, UNAWE can stimulate children from developing countries and Europe to become curious, tolerant and internationally oriented adults. Moreover, its ambition is to inspire the next generation of scientists and engineers. Above all, using astronomy as a tool to make children aware of the greatness and beauty of the universe, UNAWE obtains the development of skills such as logical reasoning, problem solving, and creativity, which are essential to maintain and further develop our society. In addition, astronomy can be also used to develop other kind of skills through interdisciplinary interventions. For instance, we can use stories about asters and space to improve children language skills and calculations about astronomical objects to improve their numerical skills.

In this chapter we have highlighted the importance of UNAWE Project. Thanks to all its activities, UNAWE plays an essential role for education, economy and society in general, exploiting every benefit of science education. UNAWE acts in a crucial age for children's development and manages to focus especially on more needy environments without neglecting others. Rather, UNAWE adapts to every situation, utilising often the help of local collaborators.

As we have seen, a fundamental part of its work is to develop astronomy educational material and make it accessible to children, teachers, educators, adults and everyone who wants profit from it.

In the next chapter we focus on this resource: astronomy educational material.

Capitolo 3

Astronomy Educational Material

In this chapter we present the UNAWE' s educational material for teaching astronomy. We focus on who developed the material, why and for what target audience. In addition, we analyse the structure that activities must have in order to meet the required standards. Finally, we examine the choice of UNAWE to make it an Open Educational Resource - OER.

3.1 Educational Resources and Their Different Types of Audience

The previous chapter, in section 2.3, describes the UNAWE' s body of activities, among which the development of educational resources represents a big part of them, both for the non-formal and informal sectors. It is important to notice that a main aspect is the possibility of using the educational material in connection with the curriculum in the formal education. This is the reason why UNAWE gives great importance and puts a lot of effort in developing new educational material and in improving the existing one.

In fact, UNAWE, since its inception, has developed a wide range of educational material. As we have seen in section 2.3.3, this material has been produced by an international network of educators and astronomers, who voluntarily contribute to create this archive of activities. In addition, to meet the high quality standards set by UNAWE itself, pedagogical and scientific contents have received particular attention, and thanks to the combined work of educators and scientists the results are excellent.

Another important aspect in activity's development is the fact that there must be in them a fun and playful side. In fact, developers should not underestimate this feature because the audience to whom activities are directed consists, as we know, of children between 4 and 10 years old. This characteristic helps to keep alive children's attention, fascinate them, make them curious and participating.

However, the pool of users is actually much larger, this is because, even if the final goal is to reach young children, UNAWE wants anyone to have access to these resources. Furthermore, this material is particularly designed to be an educational support for the teachers of these children, as well as, of course, for educators, parents, students and also directly the children themselves. Therefore, the astronomy educational material developed by UNAWE is created for young children, but tailored for teachers of pre and primary school, so that they can introduce astronomy in the curriculum with more ease and assurance. In addition, thanks to these activities, teachers are able to grasp the extreme interdisciplinary nature of astronomy and most importantly can understand and effectively explain the topics. Moreover, often new and exciting methods are used in the resources. Teachers can use them to help children to fully understand and remember for a long time the topic discussed, as well as to stimulate skills and scientific thinking. Indeed,for this purpose, UNAWE [1] provides a guideline on how the activities should be carried out in order to have the maximum effect on the public, such as for example [76]:

- Enjoy yourself, be positive, be theatrical and be ready to answer questions.
- Be enthusiastic: children will take their lead from you, so the most important tip is to be lively, engaged and interested.
- Keep things simple: concepts adults take for granted can be lost on a younger audience.
- Use analogies: instead of saying that the average Earth/Mars distance is 225 million km, explain that Mars is so far away that even in a fast rocket ship it would take six months to get there.
- Encourage creativity: astronomy is a brilliant topic for children to flex their creative muscles with.
- Know your stuff: make sure you have a reasonable level of knowledge. You never know which questions you will be asked, so be prepared.
- Spark discussions: an excellent way of keeping children involved is to encourage discussion and participation. A simple way of doing this is asking questions.
- Encourage friendly competition: children are naturally competitive and this can be used to our advantage.

[1] http://issuu.com/unawe/docs/eu-unawe_student_ambassador_guide/12

- Realise that you are appreciated: communicating astronomy to children, you will not only educate, but also inspire the next generation to take an interest in science and perhaps in astronomy.

In conclusion, UNAWE utilises a lot of work, time, resources and people for the creation of high quality educational material.

3.2 Standards

The UNAWE' s astronomy educational material consists of many different activities (about sixty, but new ones are always in development), which deal with fundamental themes of astronomy in a fun and easy way, suitable also and above all for those who is unskilled in the subject.

Most of the activities are hands-on type, such as building models to better understand certain phenomena and astronomical objects, or instruments to observe them. For example, Creating Eclipses in the Classroom is a model Sun-Earth-Moon that students can build with simple commonly used material and utilise to understand how and why solar and lunar eclipses happen; or we can cite Make a Reflective Telescope in which is explained how mirrors work with light and how build a home-made reflective telescope to use for observe the night sky.
In the UNAWE archive we also find activities on news about the latest discoveries in astronomy, such as Space Scoop Storytelling , a fun activity that aims to introduce young children to the world of science and to inspire them sharing exciting new astronomical discoveries.
In addition, there are activities that help to know the magnificent objects and events that populate our universe, sometimes combined with imagination and art, especially for younger children. We can mention Super Saturn Arts and Craft, in this activity children can explore the planet Saturn in a creative way, indeed they can use creative ideas to illustrate how Saturn's rings are formed and then make and decorate their own planet Saturn; or Icosa-Planet, this imaginative craft activity encourage children to imagine the planets of the Solar System, according to known facts, making them using a template of an icosahedron and decorating their planets with sand, glue, cotton-wool, paint, glitter.
Some activities stimulate imagination, fantasy and scientific thinking, as Your Birthday on Another Planet, in this classroom activity, students can explore their birthday on other planets. Indeed, asking questions, interpreting data, using logic, deducing, predicting, students realise that planets revolve around the Sun in the same direction, albeit at different speeds, therefore the length of a year isn't the same from one planet to the next; or like Design Your Alien, in which are examined the environmental factors that make Earth habitable and how the conditions on Earth affect life. Comparing them to another world within our Solar System and using creative thinking, children design an alien life form suited for specific environmental conditions on an extra-terrestrial world within our Solar System.

Dealing with astronomy is difficult to miss the mythology and stories related to constellations and astronomical phenomena, for instance Hercules, the Strongest and Bravest Boy of All a tale of Greek and Roman mythology that talks about constellations, A Rabbit in a Pot, Mexican legend on the Moon's phases, Tales of Wandering Stars, an Inca legend about planets, The Moon's Shame, an Indian legend on lunar eclipses.
Do not forget also the fun card and board games based on astronomical contents, such as Power Planets Card Game, a fun Solar System-style card game, or Astronomy Snakes and Ladders, a funny board game based on astronomy.

There are many other wonderful activities and for a complete list see appendix B.

It is important to underline that the development method and the structure of the activities are well defined, and anyone who creates an activity must adhere to these schemes. This is necessary to meet the quality levels desired by UNAWE. Furthermore, every contents must be scientifically accurate but it must be never forget who is the final audience, to adjust concepts and language. This triggers an initial screening of the activities, and the ones that not follow these rules are automatically rejected. Moreover, this constraint assures that all the activities have similar shape and model, facilitating quality control, possible corrections or implementations, cataloguing and publication.

The next sections describe the development method and the structural model of the activities.

3.2.1 Development Method

Every astronomy populariser is passionate about sharing astronomy widely, but it's not that simple as we can imagine. Indeed, many educational activities are significantly less effective than they could be [77].

First of all, to create a good astronomy activity we have to put our attention on designing in a careful intentional way, rather than on how hoping things will work. Moreover, evaluating how well our activity allows us to achieve our goals is another important point.

Fortunately, as we have see in chapter 1, there is a large body of education research on how people learn and how to teach effectively. If we are serious about sharing astronomy widely and effectively, we must treat our teaching like research. Namely that we must use appropriate teaching techniques supported by education research wherever possible. Therefore, we must have clear goals for our activity, evaluate how well we are achieving our goals and revise our strategies in light of what we learn.
In this purpose, when considering preparing a new educational resource or updating an existing one, it is useful to spend some time considering the goals of the programme. Indeed, a well constructed resource can assist in a student's skills

and scientific understanding, but also their enjoyment and perception of science.

A few relevant teaching principles from education researches [77] [10] [78] [79] [80] which can help design effective astronomy activities are summarised below.

Backward Design

Be strongly goal-oriented in designing and evaluating activities:

- Have clear in mind the argument of your activity and distinctly state your goals for the learners. In effect, goals are the broad concepts that you aim to address through your resource. For example:
  - Students will have an appreciation of how the Moon phases are created;
  - Students will understand the consequences of space travel.
- Make concrete your goals creating objectives: determine the evidences showing that students achieve the goals. This is very dependent on the type of resource and on the exact nature of the goals. However, by creating objectives, you will also help the students to achieve these goals. For instance, if students show enthusiasm, enjoyment, interest and fun during the activity, this is a clear evidence that is the right way forward. Likewise if they ask their own questions about the subject, if they state a desire to learn more about some topics or if they state a desire to take more science classes. Or there may be practical evidence. Such as if students are able to make a model of the Earth-Moon system and by moving the Moon to different positions are able to describe how the phase changes through the course of a month.
- Structure your activity to help learners achieve the goals and the objectives: focus on the path to follow and involve students with questions and reasonings. Moreover, give the teachers (or anyone else who might be delivering the content) ideas how they can evaluate the activity and how the students skills and understanding is developing.
- Divide the activity in theory and practice: decide the background information and expose them in a simple, clear and scientifically correct way. Think about how to demonstrate your arguments through experiments or tools.
- Consider the material to use in your hands-on demonstrations: it should not be too difficult to find, better if you can find it easily in everyday life. Moreover, when possible, involve also cultural aspects from your country.
- Include circumstances to assess students progress during and after the activity and to evaluate how well they have achieved the goals. Evaluation

should be incorporated into the activity if possible, to avoid making it a chore for the teachers and students.

- If your learners did not achieve the goals at the level you intended, use what you learned thanks to and about them to revise the activity for next time.

Choose Your Goals

When constructing your resource always consider who your audience is and choose your goals keeping in mind your students' background and considering their prior knowledge (whether it's correct, incorrect or lacking on a topic). It is important find ways to explicitly draw out students' prior knowledge or ways to allow them to explore any misconceptions, instead of reinforcing them. This is helpful for you and for students themselves. Moreover, don't forget that students with prior misconceptions are much more likely to remember/internalise a correct explanation. This happens because they compare their existing ideas to the new explanation.

The goals concern three different themes: scientific content, scientific process skills, scientific attitudes. Every theme is equally important and the activity's goals should belong to each sector. To better understand this types of goals, we see in detail what they are.

- **Scientific Content:**
  What you want students know/understand: this type of goals concerns concepts and theories to learn.

  Think very carefully about the scientific concept or topic which is at the centre of your resource and make your topic clear. It can be tempting to include too many related topics, which eventually leads to your resource losing focus. While you choose the content, consider:

  - Subjects with big, spectacular and eye-catching pictures stimulate long-lasting learning, capture children's attention and fascinate them;
  - Concepts that involve explanations, rather than just vocabulary or phenomenology, allow students to reason;
  - Topics related to everyday observations students can make, motivate interest;
  - Practical activities, that students can do and test, help topic's comprehension and give a long-lasting knowledge;
  - Arguments that expand students' minds and cool arguments are important to keep curiosity alive, even if hard for students to understand at any deep level (e.g., black holes);
  - Topics on ongoing researches let students in on the mystery-solving aspect of doing science. Moreover, these topics stimulate the desire to

pursue a career in science in the future, they show that there are many areas in which children can contribute when they are older.

- **Scientific Process Skills:**
  What we want students are able to do: this type of goals concerns skills and abilities to acquire.

  Think about what you want your students to be able to do at the end of your resource and the skills they will develop. Unfortunately, often the process skills are somewhat overlooked in designing activities, however these goals are particularly important for students. They are important especially for those who will not be scientists in the future (probably the majority of the students). Indeed, they can use the scientific approaches in every aspects of their life, if these scientific approaches are introduced correctly. For example students should learn about:

  - How to ask questions (about phenomena they see);
  - How to investigate the answer to question (by thinking and experimenting);
  - How to think analytically/critically (e.g., evaluate likelihood of a claim giving evidence, find flaws in an argument, draw logical conclusions from arguments);
  - How to solve a problem;
  - How models can represent and help us study real-life phenomena;
  - How to articulate an explanation;
  - How to work in a group;
  - How to search information.

- **Scientific Attitudes:**
  How we want students feel about science/education in general/life: this type of goals concerns attitudes, inspirations and desires to stimulate.

  By providing a resource, you want students to learn but you also want to influence how the students (and perhaps even their teachers) feel about science. Science experiments and practical sessions in school are often perceived as doing a sequence of steps to arrive at an answer, none of which give the student a deep understanding. With a good resource, students can view science as an exploration where the path is as significant as the answer. These goals make students see about science in a positive, fun and inspiring way. For instance, students should feel:

  - Inspired to pursue their education;
  - Inspired to study science further;
  - Inspired to become an astronomer;

- Connected to their culture's astronomical discoveries;
- More curious and interested in observing the world around them;
- Empowered to ask why about science observations, and beyond, in their lives;
- Empowered to figure things out for themselves;
- Connected to (and respectful of) people from different and multicultural backgrounds (getting perspective from the smallness of our planet and the vastness of the cosmos).

Things to Watch Out For

In addition to all that we have seen until now, we have to watch out for some helpful expedient and technique.

As good plan of action, you can involve multiple starting/ending points (opportunities to gain basic and advanced levels of understanding) or performing a smaller set of tasks during the course of the resource/activity. In this way students at different starting levels and with different abilities can all learn something from the activity. In addition, simply telling a concept and then having students confirm it can depicting science as memorising rather than opportunity for discovery. Indeed, in this way, science seems less interesting and students don't learn to think autonomously. Furthermore, it's good don't forget that results from experimentations are more simple to understand and remember. And also that assuming students know more than they really do can be counter-productive to their belief that they are able to learn and do science. Finally, it is also important to be aware of and don't exacerbate common misconceptions. For example that the Moon's phases are caused by Earth's shadow on the Moon.

Enquiry-Based Learning

UNAWE encourages educators to prepare their resources to incorporate enquiry-based learning approaches. Enquiry-based learning describes an approach to learning that is based on the investigation of questions, scenarios or problems - often assisted by a teacher or educator. A useful used definition is: learning which is aimed squarely at a particular set of student skills. In particular, the 5 areas of the enquiry skill-set are [81]:

- Learners engaged by scientifically oriented questions;
- Learners give priority to evidence in responding to questions;
- Learners formulate explanations from evidence;
- Learners connect explanations to scientific knowledge;
- Learners communicate and justify explanations to others.

This skill-set view can be elaborated to accommodate the student-centred elements of other views. For enquiry resource it can be considered as a hierarchical set of levels as shown in Figure 3.1.

Level of enquiry	Main responsibility for	Who carries out the procedure	Who finds the solution
Level 0 Confirmation/Verification	Teacher	Teacher	Teacher
Level 1 Structured Enquiry	Teacher	Teacher/Student	Student
Level 2 Guided Enquiry	Teacher/Student	Student/Teacher	Student
Level 3 Open Enquiry	Student	Student	Student

Figura 3.1: Basic Enquiry Model. The levels represent the degree of ownership of the skills given to the student. Traditional teaching is Level 0 and fully open-ended enquiry is Level 3.

Level 3, open enquiry, is seductive and may appear the ideal way to teach. However, the research into open enquiry or minimally guided instruction has shown it is less effective compared to traditional methods. The explanation has been given in terms of the unrealistic cognitive demands it places on novices. In effect, it presents many challenges to inexperienced students and it is unlikely to be acceptable within our contemporary standards-based education systems [81] [82]. By contrast, Level 2, guided enquiry, is much more pragmatic. It allows the teacher to retain sufficient responsibility to limit the riskiness and ensure focus on desired curriculum outcomes. Moreover, it still offers students a high degree of autonomy and pleasure of discovery as described by Richard Feynman [83]. Indeed, the research has shown Level 2 is linked with higher achievement [84]. Consequently, UNAWE believes Level 2 represents a clear, ambitious, yet realistic goal to aim for in changing teachers' practice and UNAWE encourages all the resources to use this type of approach to resource design.

In conclusion, the most important things children learn from astronomy activities are skills of questioning and investigation, analytical thinking and desire to pursue their education. Astronomical content is a mean to inspire and to interest students and it motivates them to learn.

3.2.2 Structure Model

This section describes the structure which is necessary to create an efficient activity in the UNAWE way. This is a structure model and every educational activity that is submitted to UNAWE has to follow it (Figure 3.2).

FIELD	M/O	DESCRIPTION	EXAMPLE
CODE	M	Code provided by UNAWE to catalog and organise all activities.	eu-unawe13xx (xx are increasing numbers from 01).
TITLE	M	Title of the activity, few significant words from the topic.	
LEVEL AND/OR MINIMUM AGE	M	This field specifies from which age up or over what range of age or in what school's period, students are suitable to carry out the activity.	For example: Preschool (< 6 years old), Primary School (6-11 years old), Secondary School (11 -18 years old), Higher Education (18+ years old) or 4+, 6+, 11+ and so on.
TIME	M	Minimum time necessary to carry out the activity.	For example: 30 min, 1 h, 1h 30 min and so on.
INDIVIDUAL/GROUP	O	This field specifies whether the activity is to be carried out in group or individually. If empty, it means that is indifferent.	
SUPERVISED/UNSUPERVISED	M	This field specifies whether it is necessary supervision by a teacher or an adult.	
COST	M	The range of cost that is spent on the material required in the activity.	There are three ranges: Low (<~ 5 EUR), Average (5-25 EUR), Expensive (> 25 EUR).
INDOORS/OUTDOORS	O	This field specifies whether the activity is to be carried out outdoors or indoors. If empty, it means that is indifferent.	
LANGUAGE	M	Language in which the activity is written.	
BRIEF DESCRIPTION	M	Small activity description, a few sentences that express the fundamental concepts which will be treated in the activity.	
KEYWORDS	M	Keywords that represent concepts, themes and fundamental actions of the activity.	
MATERIALS	M	List of the material that is necessary to find to carry out the activity.	With image, if it is present.
LAEARNING OBJECTIVES	M	One or two sentences that explain knowledge and skills that students should acquire with this activity.	For example: "acquire sth", "understand sth", "develop sth" and so on.
BACKGROUND INFORMATION	M	The scientific content that learners must have to carry out the activity and what they possibly will acquire after it is performed.	
INTRODUCTION	O (M)	A not mandatory introduction to the activity. (If the detailed resource description, is missing, it becomes necessary)	
COCLUSION	O (M)	A not mandatory conclusion to the activity. (If the detailed resource description, is missing, it becomes necessary)	
ADDITIONAL INFORMATION	O	This field can include notes, tips, resources, follow-up, questions, safety requirements, variations and URLs to connect to similar subjects.	
EVALUATION AND ASSESSMENT	O	Some advice, test or questions to evaluate the impact of the activity. They are useful especially for teachers and educators.	
CONNECTION TO CURRICULUM	O	All the possible connections between themes treated in the activity and the national curriculum. Specify the country.	
SOURCE/ADAPTED FROM/RELATED ACTIVITIES/AUTHOR	O	This field can contain information about the presence of source activity or if the activity is adapted from another one, about other possible related resources (created from UNAWE or from someone else) and about the author.	For example some URL to link to original material or to other activities, the author's name, so as information about the author.
COPYRIGHTS	M	Statement about copyrights (Creative Commons and Open Educational Resources).	The statement can be: Zero, Attribution-ShareAlike, Attribution-NonCommercial-ShareAlike.
RESOURCE DESCRIPTION	M	An activity full and detailed description, it includes instructions and steps to follow. (If, for any reason, this part is missing, it is mandatory to fill the introduction and conclusion fields)	With images, if they are present.
ATTACHMENTS	O	Videos, PDFs, images, presentations and everything that are useful or necessary to carry out the activity.	

Figura 3.2: Model structure of the UNAWE' s activities. We provide a brief description of every field and, moreover, mandatory fields are marked with M while optional ones with O.

For astronomy popularisers this is a precise guideline to follow that helps to create good activities and resources. When a new activity is brought to the attention of UNAWE, it is reviewed by one or more astronomers to verify that all required fields are filled and that the content is scientifically correct, sufficient and adequate. In practice, this is a small peer-review process, during which the astronomer in charge provides, if necessary, small corrections and additions. At the end of this process, teachers and educators can easily utilise the activities during their lessons, however also children can lightly carry them out. This is the basic purpose: the resources are specifically tailored for teachers and educators, but they can be used by everyone, children and adults. For a complete example of an activity's structure model see appendix C.

3.2.3 Recommendations to Write the Content

This section is based on pedagogical notions received from experts, extracted from the literature [85] and on personal experience.

There are some tips to keep in mind during the draft of an UNAWE activity's content, they are related to the final audience carries out the activity. Since the final audience is composed by young children aged 4 to 10, this definitely affects the entire content processing and writing. Nevertheless, these suggestions are also helpful for an audience of adults that are not educated about astronomy.

While you write the activity's text, consider:

- During school years, children acquire different skills and abilities in specific moments of their growth. For example, they learn the concept of space, time, density and many others. But the knowledge of these concepts occurs gradually, through increasing levels. This means that, as time passes, the knowledge and understanding of them gradually increase: therefore, consider at what understanding level, of the concepts involved in the activity, are the children to reach.

- Concepts have to be explained in the simplest way possible, included the difficult ones: try to find the way to simplify every notion you want to convey. Sometimes, there are topics or phenomena that we can not explain if children are too young: mention them without explaining, for instance the gas that composes a star is called plasma by astronomers, this is its name; or mention them only after a simple explanation, for example, talking about a cloud of gas and dust, use the term nebula only after it has been explained. Don't assume any prior astronomy knowledge.

- In the activity we have to avoid difficult words: keep language simple and use simple words the most possible. If some complex words are necessary, repeat them many time during the activity, thereby maybe children can remember them. In general keep sentences short and simple, try to keep the technical jargon to an absolute minimum and avoid the use of colloquial language.

- It is better to focus on just a couple of concepts: don't overwhelm the children with too many new terms, names or concepts.

- References to popular culture and fairy-tales make the activities for children attractive. Beyond this, they can also be useful for explaining difficult topics in a fun way. It's important to keep in mind that the references must be familiar to the young audience.

- Examples are very useful to remember notions: make many examples, also from the everyday life, if possible. Moreover, a good way to relate new concepts to familiar ideas is using metaphors (e.g. pulsing stars swell and shrink regularly, like a heartbeat). Every time that it is possible, insert links to experiments or hand-on activities.

- Last, but not least, mistakes and failures help to show that scientists are real people: don't shy away from telling children how much we still don't know about the Universe.

If developers follow these advices, the result will surely be an attractive, engaging and clear activity. The activity will be capable to transmit the desired knowledge in a profitable and long-lasting way. Furthermore, it will stimulate scientific thinking and skills in the right way, fundamental goal for the astronomy educational material.

3.3 Distribution and Sharing

Each historical era creates a system of education that addresses its needs [86]. During tough economic times the educational system gets damage, due to the reduction of education funding [87], making knowledge transfer a difficult task.

For this reason, although learning resources are often considered as key intellectual property in a competitive education world, more and more institutions and individuals are sharing learning resources openly and without cost [88]. The freely accessible resources that openly share educational content and that are useful for teaching, learning, educational, assessment and research purposes are called Open Educational Resources (OERs) [89].

In light of all this, UNAWE has decided to distribute and sharing its astronomy educational material as OER through its web site [2]. The choice turned out to be exact, indeed, UNAWE' s commitment, to maintain this choice and keep its quality standards, was rewarded: the UNAWE educational resources have been recognised for their educational value by Science Magazine with its 2011 Science Prize for Online Resources in Education (SPORE) award. UNAWE' s

[2] www.unawe.org

OERs totally reflect the important concept of the 4 As (accessible, appropriate, accredited, affordable): if resources are easily accessible and rewarded with formal accreditation, the content is appropriate and learning is affordable, the chances of success are significantly increased [90].

3.3.1 Open Educational Resources - OER

OERs have been inspired by the success of open source software projects, which are computer programmes whose source code is published with a copyright that allows anyone to copy, modify and redistribute the code and its modifications. In general terms, software is considered free – or *open* – if it is possible to use, contribute to and share the source code. The trend towards sharing software programmes, research outcomes and resources is already so strong that it is generally thought of as a movement: OER movement citehylen2007.

The growing interest in OER is based on the vision of unlocking knowledge and empowering minds, driven by the belief that all human beings are endowed with capacity to learn, improve and progress and that education must be accessible to all without constraint [91].

Another interesting circumstance is that, at the beginning of the new millennium, the amount of educational content freely available on the Web was large and growing exponentially [92]. This content has generated new forms of education that allow the spread of knowledge using online content. Moreover, the International Telecommunications Union [93] estimate that one third of the 7 billion people in the World are using Internet (Figure 3.3), and 45% of the world's Internet users are below the age of 25, making Internet the best way to connect people and a good option to spread knowledge.

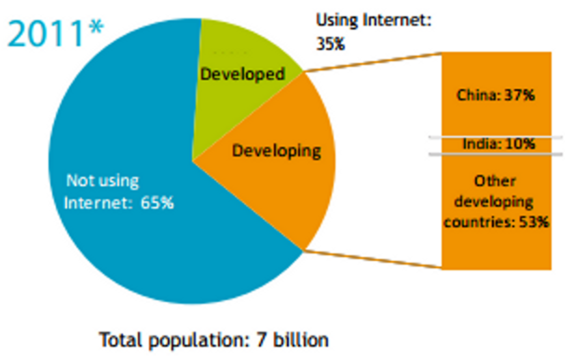


Figura 3.3: Share of Internet users in the total population. Source: ITU World Telecommunication/ICT Indicators database.

Therefore, due to the Internet functionalities and potential users, the OERs establish in the World Wide Web the perfect environment to spread knowledge and educational opportunities all around the world, improving the way of learning, teaching and research. They offer a new approach, that includes, in the main core, the learner as a participant.

Moreover, the continuous development of information and communications technologies becomes one of the drivers of the knowledge economy (Figure 3.4) and the e-learning (use of electronic media and information and communication technologies in education) is becoming part of the mainstream of educational programmes. In this scenario, the OER phenomenon can be seen as the emergence of creative participation in the development of digital content in the education sector [88].

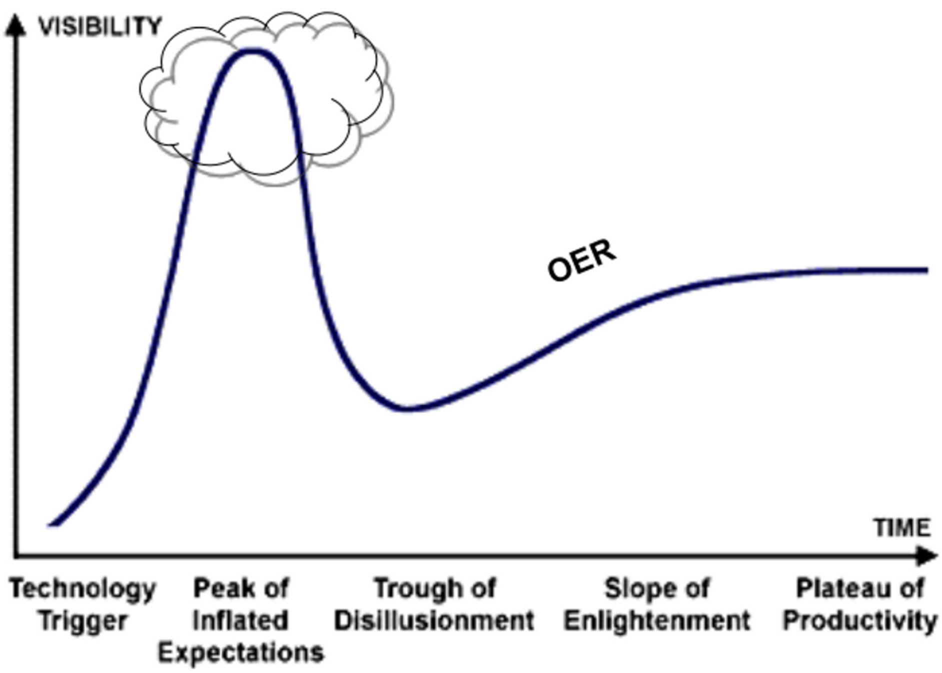


Figura 3.4: Hype cycle of emerging technology.

Nevertheless, the collective understanding of the definition of OER is maturing in parallel with increased adoption of open education in formal education institutions around the world. A definition of OER ideally needs to incorporate three interrelated and fundamental dimensions [94]:

- **Educational values: OER should be free** This idea involves two elements which need to be considered under the meaning of free in OER:

  - OER must be accessible at no-cost to the user (gratis);
  - OER should respect the freedom of the users, the freedom or permission to act without restriction (liberty).

- **Pedagogical utility: OER should embed the permissions of the 4 Rs (reuse, revise, remix and redistribute)** Open content, then, is content that is licensed in a manner that provides users with the right to make more kinds of uses than those normally permitted under the law - at no cost to the user. The primary permissions or usage rights open content is concerned with are expressed in the 4 Rs Framework. Namely that with OER you are free to [95]:

  - Reuse: the right to reuse the content in its unaltered/verbatim form (e.g., make a backup copy of the content);
  - Revise: the right to adapt, adjust, modify, or alter the content itself (e.g., translate the content into another language);
  - Remix: the right to combine the original or revised content with other content to create something new (e.g., incorporate the content into a mash-up);
  - Redistribute: the right to share copies of the original content, your revisions, or your remixes with others (e.g., give a copy of the content to a friend).

- **Technology enablers: technology and media choices should not restrict the permissions of the 4 Rs framework** Digital technologies are the enablers for the 4 Rs above. However, technology and media choices can also restrict the 4 Rs activities. There are two important considerations pertaining to technology and media choices for OER:

  - Access to the tools required for editing, revising and remixing OER content: all users should be free to use the software of their choice;
  - Ensuring that OER is meaningfully editable: all users have the capacity to edit an OER to suit their local needs.

Since many challenges have emerged during the maturation of OER concept and the evolution of OER movement, most of them related with quality and openness of the online materials, in 2002 the concept of Open Educational Resource was first introduced at a conference hosted by UNESCO.

The UNESCO forum defined Open Educational Resources as the open provision of educational resources, enabled by information and communication technologies, for consultation, use and adaptation by a community of users for non-commercial purposes [96]. Later, the restriction to non-commercial purposes was removed, and more recently the definition has been expanded to include also non-digital materials [97]. A frequently used definition of OER is the one provided by

one of the key funders of OER initiatives around the world, the William and Flora Hewlett Foundation [3] [99]: OER are teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others [86].
Open Educational Resources include learning content (full courses, course materials, content modules, textbooks, learning objects, journals, streaming videos, tests, etc.), tools (software, and any other tools, materials, or techniques used to support the development, use, reuse and delivery of learning content and used to support access to knowledge) and implementation resources (intellectual property licences to promote open publishing of materials, design principles of best practice and localise content) [88].

Nevertheless, the definition of OER currently most often used is: digitised materials offered freely and openly for educators, students and self-learners to use and reuse for teaching, learning and research (Organisation for Economic Cooperation and Development - OECD, [88]).

These definitions are intuitive, but they can be made more accurate by defining what we mean by resources and openness.

According to a dictionary definition, a resource is a stock or supply of materials or assets that can be drawn in order to function effectively [88].

Instead, the concept of openness must be carefully understood. This idea is related to freedom to disseminate, contribute and share freely the knowledge through the world with few restrictions on the use of the resource. This means that while open means without cost, it does not follow that it also means without conditions. Furthermore, a higher level of openness is about the right and ability to modify, repackage and add value to the resource. This kind of openness blurs the traditional distinction between the consumer and the producer [100]. This because, when OER is produced in a collaborative fashion, where the use and remixing of the content increases the value of the resource, the separation between consumption and production breaks down [86].

In conclusion, a fairly complete way of describing open educational resources is to define them as accumulated teaching, learning and research assets that can be adjusted and which produce services that anyone can enjoy, without reducing the possibilities of others to enjoy them or without destroying the stock, as it is often the case with digital resources. In economic terms, this means that the resources are non-rival or renewable or public goods. It is not simply that such resources are available to anyone despite their use by others; in some cases the resource becomes more valuable as more people use it. When the value of the resource is enlarged with use, the resource is an open fountain of goods. In an open fountain

[3] It's a private foundation, established by Hewlett-Packard co-founder William Redington Hewlett and his wife Flora Lamson Hewlett. The Hewlett Foundation awards grants to support educational and cultural institutions and to advance certain social and environmental issues. It is one of the largest grant-giving institutions in the United States [98].

model, the more the pool is used, the bigger it gets. Furthermore, to be open means that the resources provide non-discriminatory access to their content and they can also be contributed to and shared by anyone (Figure 3.5) [88].

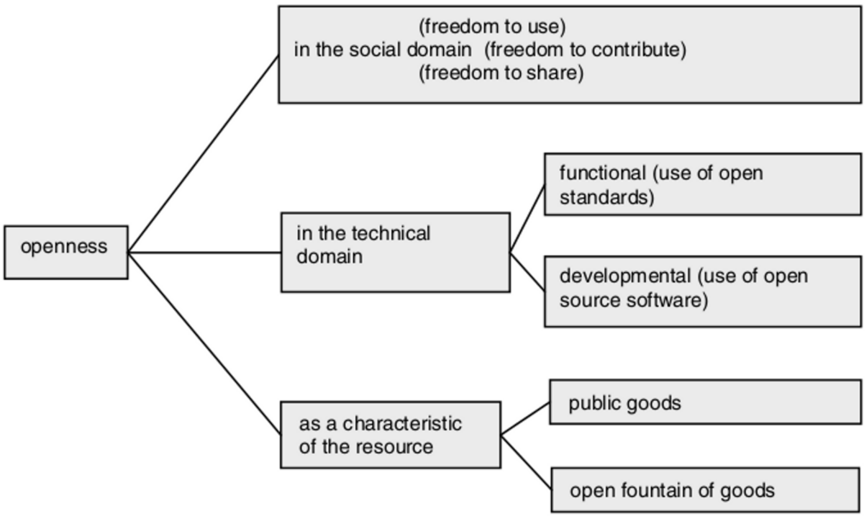


Figura 3.5: Aspects of openness.

It is interesting notice that education and science have a long-standing tradition of openness and sharing. The OER movement is but the latest example. Institutions are experimenting with new ways of producing, using and distributing learning content, novel forms of covering their costs and more efficient ways of attracting students. [88]

3.3.2 Perspectives and Difficulties

The Open Educational Resources model offers a new vision of learning in a powerful way, based on the statement that the world's knowledge is a public good. Moreover, OER model offers a good schema to reinforce education system all around the world, improving the way of learning, teaching and research. Therefore, OER is not only a fascinating technological development and potentially a major educational tool. It accelerates the blurring of the boundaries between formal and informal learning, and of educational and broader cultural activities. In effect, OERs can make an important contribution to a diversified supply of learning resources. Furthermore, OER offers the prospect of a radically new approach to the sharing of knowledge, at a time when effective use of knowledge is seen more and more as the key to economic success, for both individuals and nations. All this thanks to the fact that OERs are convenient, effective, affordable, sustainable and available to every learner and teacher worldwide [88]. In effect, Open Educational Resources are now viewed as a natural way to implement distance learning, open education and new pedagogical approaches [86]. The need and desire to make education and knowledge more equitably available and the growing network of connectivity around the globe have allowed to achieve this goal [101].

It's important understand that sharing knowledge through making educational resources openly and freely available is a powerful means to support the development of learning societies and knowledge societies [101]. Indeed, to remain human and liveable, knowledge societies will have to be societies of shared knowledge. The potential offered by a rational and purposeful use of the new technologies offers real prospects for human and sustainable development and for the building of more democratic societies [102].

In support of these arguments, there are multiple reasons for which individuals, teachers, researchers, institutions and governments should use, produce and share OERs. We can name a few (extracted by the literature [103]; [104]; [105]; [88]):

- OER' s quality can be improved and content is cheaper and easier to produce and costs can be further reduced by sharing and reusing;
- New economic models are emerging around the distribution of free content;
- A review of existing copyright regime has been started creating new licensing schemes that facilitate free sharing and reuse of content;
- Interoperability grows: the ability of a system or of a computer product to cooperate and exchange information with other systems or services or products in a more or less complete and error-free way, with reliability and with optimisation of resources [106];
- Awareness-raising activities are stimulated;
- OERs expand access to learning for everyone, but most of all for non-traditional groups of students. Moreover, OER project attracts new students;
- Lifelong learning and wider participation in education can be promoted efficiently;
- The gap between non-formal, informal and formal learning can be bridged;
- Open sharing speeds up the development of new learning resources, stimulates internal improvement, innovation and reuse and helps the institution to keep good records of materials and their use;
- Sharing is a good thing to do, it stimulates further innovation, it offers personal satisfaction to know that one's materials are available and used

all over the world and it is a pleasure to develop things together with peers and share with others;

- Publicity, reputation within the open community and possibilities for future publication are involved;
- It is a good way to assist developing countries, to make disadvantaged communities aware and to bring down costs for students;
- Sometimes it is not worth the effort to keep a resource closed. If it can be of value to other people, one should just share it freely.

As every big phenomenon that has a far-reaching impact, all the OER' s merits are not widely recognised in society yet and as rising model [92], now OERs are full of goals to reach, but also of challenges and changes to face.

Indeed, despite the growing availability of resources, the reuse of OERs by educators within their teaching remains a challenge [107], because most of the material that becomes openness is not created with that finality, those resources were thought to be used for a face-to-face teaching context, under a more traditional educational plan. The problem has its seat in the lack of a guidance for evaluating existing teaching materials and turning them into OER. The need is to formulate and use indicative questions against which existing resources can be assessed on quality, ease of access, adaptability and potential usefulness [91].
Moreover, copyright is not considered, due to it is thought that is not necessary [91]. In effect, in contrast to the well-developed practice of citation in research work, sometimes teachers have a narrow notion of licensing and copyright of teaching materials, consistent with a limited experience of sharing teaching materials [108].
Other barriers are of technical, economical and social type (Figure 3.6). They lie in the complex structure of the Web, in the lack of broadband availability, in the lack of resources to invest in hardware and software for developing and sharing OERs. Barriers such as these are often mentioned a significant obstacles in developing countries. Furthermore it is necessary consider the lack of skills to use the technical innovations and cultural obstacles against sharing or using resources developed by other teachers or institutions [88].

Difficulties occupy also the policies at different levels, within institutions and governments, they involve changes in educational traditions and these changes make difficult creation and use of open material. In addition, OERs rise to threaten the monopoly on scientific knowledge held by commercial publishing houses [88].

3.3.3 Promise for the Future

OERs will contribute to the promise of education for all providing free educational materials to everyone in the world [101]. This thanks to the powerful idea that the world's knowledge is a public good and that technology in general and the

Underlying drivers	Underlying inhibitors
Technical: Increased broadband availability; increased hard drive capacity and processing speed; new and improved technologies to create, distribute and share content; simpler software for creating, editing and remixing.	Technical: Lack of broadband and other technical innovations
Economic: Lower costs for broadband, hardware and software; new economic models built around free content for recovering costs.	Economic: Lack of resources to invest in broadband, hardware and software. Difficulties to cover costs for developing OER or sustaining an OER project in the long run.
Social: Increased use of broadband, the desire for interactivity, increased skills and willingness to share, contribute and create online communities.	Social: Absence of technical skills, unwillingness to share or use resources produced by someone else.
Legal: New licensing regimes facilitating sharing of free content.	Legal: Prohibition to use copyrighted materials without consent.

Figura 3.6: Drivers and inhibitors for developing and sharing OERs.

World Wide Web in particular provide an extraordinary opportunity for everyone to share, use, and reuse that knowledge [92].

Indeed, the extremely rapid expansion of OER initiatives and the millions of learners they attract can be understood as an indicator of an emerging revolution in education and learning. OER reorganises the boundaries of social transparency and it enables new forms of collaboration and production [86]. Moreover, as an indication of a widely shared belief that OER is going to be a fundamentally important phenomenon for the future of learning and education, the UNESCO World OER Congress in June 2012 released the Paris OER Declaration [97], which requests the member states to foster and facilitate the use and development of OER [86].

We underline that the diffusion and impact of OERs partly depend on whether they make the current educational system more productive and effective. OERs can help current educational institutions to adapt to emerging new social requirements. They can also provide a breeding ground for qualitatively new systems of learning that emerge outside current institutional frameworks. Furthermore, one of the main goal of a widely use of OERs is to reduce the inequalities of educational systems all around the world [86]. This fact does viable a development through educational projects [109] and it is exactly what educational projects like UNAWE aims. Ultimately, for UNAWE, OER turns out to be the best tool to achieve its goals. In its intrinsic nature, this tool has a promise of success and in effect it is the way that UNAWE has chosen to pursue.

Conclusions

We have seen in this third chapter the UNAWE' s commitment in the development and maintenance of high quality astronomy educational material.

The quality concerns scientific and pedagogical aspects and for this reason UNAWE, with help of experts in these sectors, has chosen to formulate a scheme to develop good activities. This scheme concerns every activity aspect: from design to performance in the classroom, through the choice of goals and contents, the practical activities, the writing text and so on. It is become a real guideline to follow for developing educational resources.
In addition to all this, every resource brought to the attention of UNAWE is revised for scientifically correct content by the astronomer in charge. This a peer-review process helpful to assure the high quality.

Another interesting choice of UNAWE is to distribute and share its educational resources as Open Educational Resources through its website. In this way UNAWE gives free access at its resources for every kind of educational purpose. As we have seen, this is a pondered choice, based on a new vision of learning and on the belief that the knowledge is a public good. Moreover, this method of sharing and distribution makes knowledge also an inexhaustible open fountain of goods.

All these are the right tools to reach the goals of education for all in the world and development of disadvantaged environments, this is the way for the success.

Nevertheless, as every young phenomenon, in addition to merits there are also many difficulties and challenges to achieve the promises for the future. In fact, one of the most important current problems concern the difficulty to find good educational resources in the big basin full of too many resources. Furthermore, it's difficult to know how to be sure of the high quality and of the update of these resources.

Ultimately, these are the actual points on which we have to focus now and UNAWE is trying to solve them in the astronomy educational material sector. Indeed, UNAWE is preparing a new repository of resources, with old and new activities, in order to make operative a new Peer-review Platform for Astronomy Educational Resources.

The Peer-review Platform for Astronomy Educational Resources is the focus of the next chapter.

Capitolo 4

Peer-Review Platform

In this chapter we discuss the problems of searchability and quality assessment related to the increasing number of OERs. In addition, we present the solution proposed by UNAWE to solve these problems, namely a new Peer-Review Platform. Afterwards, we analyse the strategy adopted to achieve high quality standards, inspired by peer review in scientific research. Moreover, we describe the tools that UNAWE has chosen to disseminate the educational activities through its website. Finally, we discuss the linguistic and cultural difficulties and possible solutions that arise in aiming for a global audience. We conclude the chapter with some ideas to increase the future available services and tools.

4.1 The Finding, Evaluating and Updating Problems

There are many sources of educational resources for astronomy across the world. There are also many repositories or self-professed one-stop shops which collate these resources. With some exceptions, however, the materials are scattered and thus difficult to find and use [92].

Therefore, one of the challenges facing the OER movement is due to its own success. Indeed, the rapidly growing number of learning materials and repositories has made complicated the issue of how to find the resources that are most relevant, of best quality and updated. There is a need for effective search and discovery tools. In effect, items of interest to a teacher or researcher may not be part of library catalogues, federated databases or online journal subscriptions. Many reside in local databases, available via the web but difficult to locate and essentially invisible to the scholar [88]. Moreover, the quality of these resources is highly variable, the guarantees necessary to ensure their quality lack and their effectiveness is an unknown quantity to the end user.

Although there are more than 3000 open access courses (opencourseware) currently available from over 300 universities worldwide [110], with different type of materials, there are not many certificated sources of educational resources specifically for astronomy. Unfortunately, there are just three recognised repositories for astronomy educational resources and at the end of this 2013 they will be only two:

- *The Science Mission Directorate Space Science Education Resource Directory (SSERD)* [111]: is a convenient way to find NASA space science products to use in classrooms, science museums, planetariums and other settings. They are useful at every educational level (elementary, middle and high school, some higher and informal education), but exclusively for teachers and educators. Also videos, posters and CD-ROMs are available. Regrettably, SSERD will be closed by the end of 2013.

- *The ComPADRE Digital Library* [112]: is a joint collaboration between some American science associations (American Association of Physics Teachers - AAPT, American Astronomical Society - AAS, American Institute of Physics - AIP, American Physical Society - APS and Society of Physics Students - SPS) and the biggest network of free online scientific resource collections (National Science Digital Library - NSDL). The ComPADRE Digital Library supports faculty, students and teachers in physics and astronomy education. It has material for all levels of education only in English. Moreover, an online review process for collection's resources is in development.

- *NASA Wavelength* [113]: the new NASA online science resource available for teachers, educators and students. It helps bring Earth, the Solar System and the Universe into schools and homes. The site features hundreds of resources organised by topic and audience level from elementary to college, and out-of-school programmes that span the extent of NASA science. Furthermore, educators at all levels can locate educational resources through information on educational standards, subjects and keywords and other relevant details, such as learning time required to carry out a lesson or an activity, cost of materials and more.

Though the information collated in those repositories is well organised and of high quality, however none of those repositories satisfies completely the 4 Rs framework that we have seen in section 3.3.1 (Figure 4.1). Indeed, the material can not be revised or remixed; it only, in most of the cases, can be redistributed and reused. In most of the case because, for example, to permit the use of images from the SeaWiFS sensor [1] [114] [115], NASA has a special policy that depends of the time of publication: images older than five years, belong to the public domain. Another instance is that the right to use a resource can be limited

[1] Sea-viewing Wide Field-of-view Sensor. It was the only scientific instrument on GeoEye's OrbView-2 (AKA SeaStar) satellite and was a follow-on experiment to the Coastal Zone Colour Scanner. The instrument was specifically designed to monitor ocean characteristics such as chlorophyll-a concentration and water clarity.

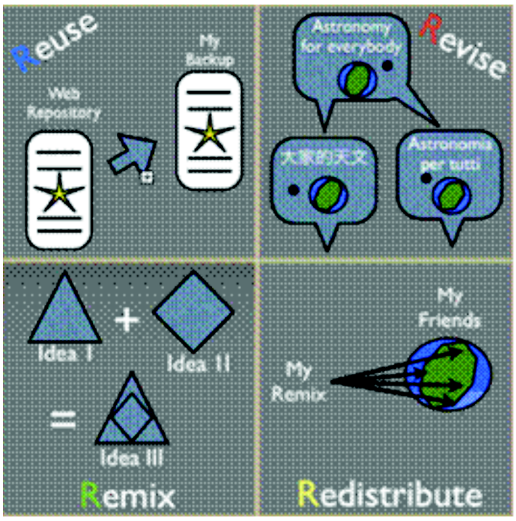


Figura 4.1: The 4 Rs framework provided by D. Wiley.

in some instances to a specific geographical area, such as a country or a region. This is the case of the BCcampus Project in British Columbia, Canada, which has developed a licence to make learning resources openly available only in the province [88]. Moreover, all the material on those repositories are in English and without the source file, translating the material is a difficult task and therefore the openness task is not fulfilled.

Because of this lack of repositories, the users must look for material in simple search engines, dominated by Google with more than the 80% of the Internet population [116], instead of academics sites. However, the use of search engines is the best alternative when there is no information about an academic source.

Indeed, a single query on Google, for example, reads hundreds of megabytes of data and consumes ten of billions of CPU cycles. In addition, supporting a peak request stream of thousands of queries per second requires an infrastructure comparable in size to that of the largest supercomputer installations [117]. This means that the use of Google is a good alternative for a quick, easy and satisfactory search of online information. At least in principle, it guarantees that the information could be found, but without knowing the quality. Nevertheless, when there are too many results from a search for learning materials, it is difficult and time-consuming to find the resources that are most relevant and of highest quality. One more time this recalls, indeed, the problem of relevance and quality. Though techniques and technologies are developed to help give teachers and students options for narrowing their search, however this is not enough to solve the problem [88].

Fortunately, there are additional technical solutions to this problem, such as attaching meta-data (data about data or descriptive information about materials) to the resources to make them easier to find for the machines utilised by users via search interfaces. Yet, adding meta-data to a resource is time-consuming and faces the problem that the person adding meta-data does not know the circumstances under which people will use the resource, so that it will be difficult or impossible to find the resource. It's necessary consider that although a lot of work has been put into creating meta-data schemes that can work across countries, languages and cultures, the lack of a common taxonomy is another significant barrier that needs to be overcome to improve the possibility of finding relevant learning resources [88].

Ultimately, even if various ways of improving access and usefulness have been introduced, there is still a real need to increase access to and the usefulness of existing resources. In effect, one seeks to make it easier for users to find relevant resources of good quality, particularly those that travel well, by using different quality management processes and meta-data to facilitate the search for resources. Efforts to increase access also include improved awareness of the need for localisation – not only translation – of learning resources and the application of Web Accessibility Initiative (WAI) [2] rules when designing websites and learning resources [88].

In conclusion, nowadays learning can be done anywhere and the OERs offer a good alternative to share knowledge all around the world. Moreover, as we have seen in section 3.3, putting high quality Open Educational Resources on the Web is the best way to share them. Therefore, since the idea of reusing, redistributing, revising and remixing the materials is innate in the concept of OER, learning resources need to be searchable across repositories and possible to download, integrate and adapt across platforms [88].

Specifically in astronomy field, it is necessary to create an online repository considering the Search Engine Optimisation (SEO) [3]. This assures quality and openness of the information and easy reaching from any search engine. Indeed, an online openness repository will provide the motivation to share quality information, which is guaranteed with referees and with the simple fact of being on the Web.

Furthermore, we underline that high quality open material will reduce the inequalities in educational system, offering to the developing countries essential educational material. Basically, such a repository could be create and it would be extremely useful in all branches of knowledge, not only in astronomy.

[2]WAI is an effort to improve the accessibility of the World Wide Web (WWW) for people with disabilities. Since people with disabilities often require non-standard devices and browsers, making websites more accessible also benefits a wide range of user agents and devices, including mobile devices, which have limited resources [118].

[3]The process of affecting the visibility of a website or a web page in a search engine's natural or unpaid search results

4.2 The UNAWE' s Solution

In order to resolve the problems of quality and availability we have seen in the previous section, UNAWE proposes the creation of a platform for astronomy communicators to discover, submit, review, redistribute and remix educational resources. A platform that provides a method for people to submit their Open Educational Resources, to have them reviewed, to obtain objective guidance on the resources, to have successful resources published in a central repository and to receive an adequate approval/accreditation from the International Astronomy Union - IAU. Indeed, using the brand or reputation of an institution, it is more simple to persuade the user that the materials on the website are of good quality. If not, the prestige of the institution is at risk [88]. In this regard, fortunately, the UNAWE' s platform project is under the framework of the IAU Office of Astronomy for Development (Figure 4.2). Besides all, the submitter will also be able to apply the Creative Commons licence more appropriate to the resource.

Figura 4.2: IAU logo that will be present in the platform to accredit the quality.

The repository assures the openness of the information and above all the quality. The platform is based on an extension of Wiley's 4 Rs framework explained in section 3.3.1 and showed before (section 4.1). Therefore, not only it fulfils all the 4 Rs but also becomes a 5 Rs framework (Figure 4.3) [119], with a fifth R in addition:

- **Review**: content and quality reviewed and improved by a community of peers.

Considering quality the main topic when searching for learning resources online [108], thus there is the need to warrant that material is of high quality and updated. The judging of the materials' quality can be reached in two ways:

- Intrinsically: the audience naturally evaluates the material. Moreover, the perceived quality of work, when authors place information on the Web, puts them under the pressure of compromising their reputation [120].

- Extrinsically: one or more expert referees evaluate and make comments about the material.

The quality-control mechanisms have therefore to provide ways for outsiders or users to assess the usefulness and quality of the material or require peer-reviewers' participation [92]. In this way, putting first the review process, the

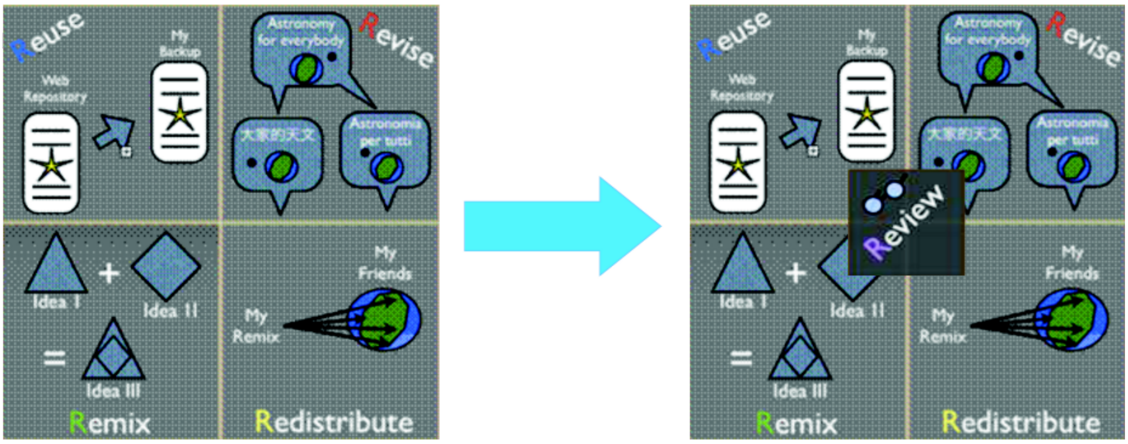


Figura 4.3: From 4 Rs to 5 Rs Resource Repository Model.

OERs become a powerful tool for learning, teaching and research offering high quality material.

Similarly, in order to develop and carry out such a OERs' project, it is necessary take under consideration what is important to the producers of open content. In this regard, the OECD submitted a questionnaire to many OERs producers and as is shown in Figure 4.4, the factors ranked as most important were to be acknowledged as the creator of a resource when it is used and when it is adapted or changed and to have a quality review of the resource. Financial compensation either to the creator him/herself or to his/her research group or department was considered the least important factor. This may suggest that many of those involved in producing OER are enthusiasts and people looking mostly for non-monetary gains [88]. The questionnaire's result can be an important positive factor for the prosperous growth of the repository.

Nonetheless, the problems to face off are various. We can name a few, such as the lack of a reward system for teachers and researchers to devote time and energy to develop OER, the lack of awareness about the advantages of OER or skills to use or produce such content or tools, as well as the lack of time. Another barrier might be that learning resources are context-bound and need to be localised, which might be prohibited (if a licence with No Derivatives clause is applied), difficult, time-consuming or expensive. It is necessary also include the prohibition to use copyrighted materials without the consent of the creator [88]. Ultimately, difficulties, tasks and important things to take care are really many (Figure 4.5) and they make difficult the realisation of the project.

However, considering the situation, UNAWE has conceived and designed a Peer-Review Platform for Educational Resources that does not neglect any of

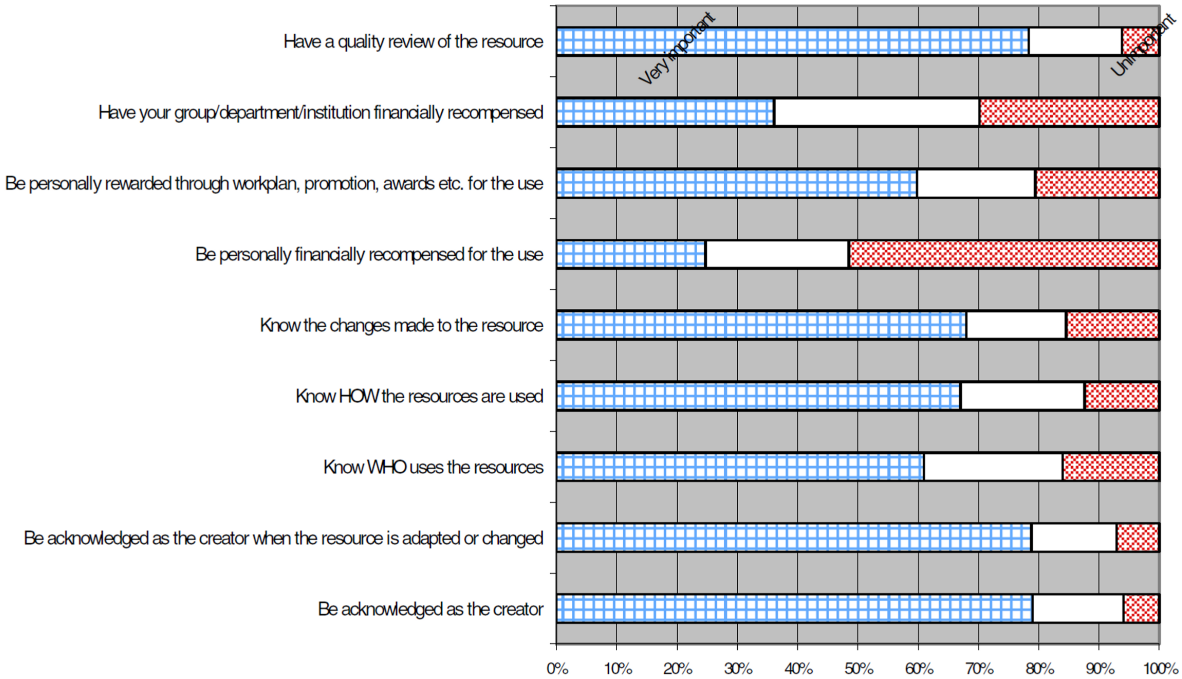


Figura 4.4: What is important to a producer of open content. Questions submitted to many OERs producers by OECD with the response rate on x-axis. Source: OECD, 2007.

these aspects and will be able to evolve in the future, if necessary, to meet changing needs.

Indeed, the UNAWE' s new repository enables gathering descriptions and instructions for educational activities prepared by teachers, educators and organisations from member and network countries. Moreover, all materials are stored in a database, using standards which enable a wide and easy sharing. Of course, the existing educational activities will be transferred in the new repository after the review. This process will also include a digitisation of older resources, when necessary. The whole database's creation is made a little easier, thanks to the process of readjustment of resources according to the standards required by UNAWE and by OERs we have seen in chapter 3. Furthermore, to ensure the highest quality, even more scrupulous scientific, pedagogical and linguistic controls are applied, which involve several experts in the various fields. All this to remove barriers to the creation, use, re-use and distribution of high-quality content.
It is important also highlight that a centralised, web-based distribution system for educational material will be implemented in a range of languages. In effect, resources can be submitted in each of the languages of the reviewers. The key is to make a network as large and as diverse as possible, so the act of reviewing is not too large a burden for an individual.

Furthermore, successful resources will be translated into every attainable lan-

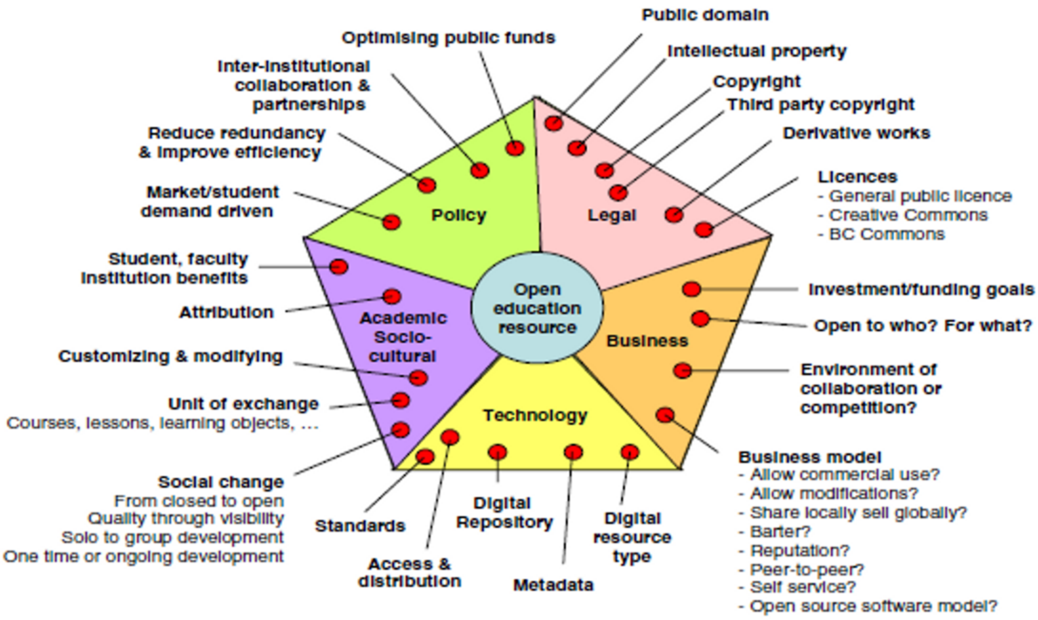


Figura 4.5: An OER project's attributes and decision points. Source: Stacey and Rominger, 2006.

guages and be made available in many different formats - from prints to mobile device apps. For instance PDF (print quality and low-res), DOC, ODT, HTML, EPUB, MOBI, etc., including the source files (RTF), useful for future translations and remixes. These successful resources will be syndicated through document sharing sites (OER Common [4], Issuu [5], Slideshare [6], Scientix [7] and other social media networks or repositories) and thanks to projects that seek to improve understanding of the demand for openly available content.

Effectively, the increasing use of Internet and social networks allows users to interact and collaborate in new ways and allows teachers and experts to create a network where they can participate collaboratively in the processes of design, development, sharing, reusing and evaluation of open learning resources. Therefore, the main objective is to provide to community of teachers and educators an online platform to collaboratively share and produce learning resources [121].

Indeed, the design and creation of the repository has already begun and partially put into practice, but we will deepen the topic later in this chapter. Moreover, we want to emphasise that the need for scientific and pedagogical quality,

[4]http://www.oercommons.org/
[5]http://www.issuu.com/
[6]http://www.slideshare.net/
[7]http://www.scientix.eu/web/guest

didactic feasibility, efficiency and speed of research of educational materials in astronomy, has pushed and led the idea of the Peer-Review Platform. But the real inspiration is the procedure of selection of papers, carried out by journals in scientific field, that we analyse in the next section.

4.2.1 Peer-Review in Scientific Research

In the context of scientific research peer review (also known as refereeing) means the procedure for the selection of articles proposed by members of the scientific community. Peer review is therefore the evaluation of work by one or more people of similar competence to the producers of the work (peers). It constitutes a form of self-regulation by qualified members of a profession within the relevant field. Peer review methods are employed to maintain standards of quality, improve performance and provide credibility [122].

Practically, an author subjects a scholarly work, research or ideas to the scrutiny of others who are experts in the same field, before a paper describing this work is published in a scientific journal. Indeed, when the research is sent to a journal for publication, the editor invites several (usually two or more) independent experts (known as referees or reviewers) to assess the credibility of this research [122].

This process encourages authors to meet the accepted standards of their discipline and prevents the dissemination of irrelevant findings, unwarranted claims, unacceptable interpretations and personal views [123].

As a result of this process, the work may be rejected, accepted or considered acceptable with revisions. Indeed, if a paper does not fully meet the requirements, based on peer reviews, the publisher can accept it after adequate changes, allowing the authors to review and change their article [123].

The peer review process ensures that an article clearly explains how the research was done, so that it can be replicated by others. Moreover, the peer review process checks that the methodology is appropriate for that specific field and for those specific goals. Another crucial part of the review process is to establish the originality of the new research and the accuracy of the references of published related researches. The main objective of this process is essentially to separate facts from speculation and from personal opinion [123]. Nevertheless, the peer review process does not protect against misconduct. In fact, it can identify errors, but it is based on honesty and it may not recognise a deliberately fraudulent research. Therefore, with the aim to reduce such occurrences, several organisations have produced guidelines of integrity on the practice of a good research. On the other hand, financial or personal issues could affect the objectivity and judgement of a professional proofreader. According to the European Science Foundation [8], it is

[8] The European Science Foundation (ESF) is an association of 72 member organisations devoted to scientific research in 30 European countries. It is an independent, non-governmental, non-profit organisation that facilitates cooperation and collaboration in European research and

crucial prevent and manage such conflicts of interest to ensure the fairness and integrity [124].

It is known that the process and the culture of mutual control of the work is in progress in the scientific world. However, the peer-reviewed research is not protected against criticism and any obtained conclusion must be considered in the context of other studies. In effect, once the article is published, further critiques are possible from the scientific community through letters to the editor of the journal, discussions at conferences or direct exchanges with researchers of the study in question. The authors can justify their findings and they can correct or retract the possible concealed defects [122] [123].

This is the nature of science, all jobs are open to criticism by other scientists. For this reason UNAWE has chosen to follow the peer-review process as base in its Peer-Review Platform.

4.3 Fulfilling the 5 Rs Framework

As we have seen in the previous section 4.1, the rapid increase in high-quality Open Educational Resources has made it imperative to establish well-organised and useful portals and platforms. Without such sites, users will never be able to take full advantage of OERs. An advantage of a platform is that it can point to large amounts of material across the Web. But to maintain its quality, the platform requires constant attention to ensure that the cited materials continue to be available and valuable. A repository overcomes that problem by controlling the material. Indeed, the quality of the material would be vetted through peer reviews and testing by users. Moreover, since the content would be free and open, we can think of this model as an interactive and very high-quality free textbook [92].
In the same way, the peer-review process is one of the most used quality assurance processes in academia. In addition to being well-known and well-understood, using peer review scheme to guarantee the quality of a repository's resources is the basis for dissemination [88].

In conclusion it is possible to schematise the process UNAWE has decided to follow to build and implement its platform with the Figure 4.6 below.

As a result of this process, the UNAWE' s Peer-Review Platform, inspired by the peer-review in scientific research, satisfies all the 5 Rs framework seen in section 4.2.

4.3.1 Submission

The first level of the peer-review process in the platform concerns first of all the registration of the author and then the submission of the resource.

development, European science policy and science strategy.

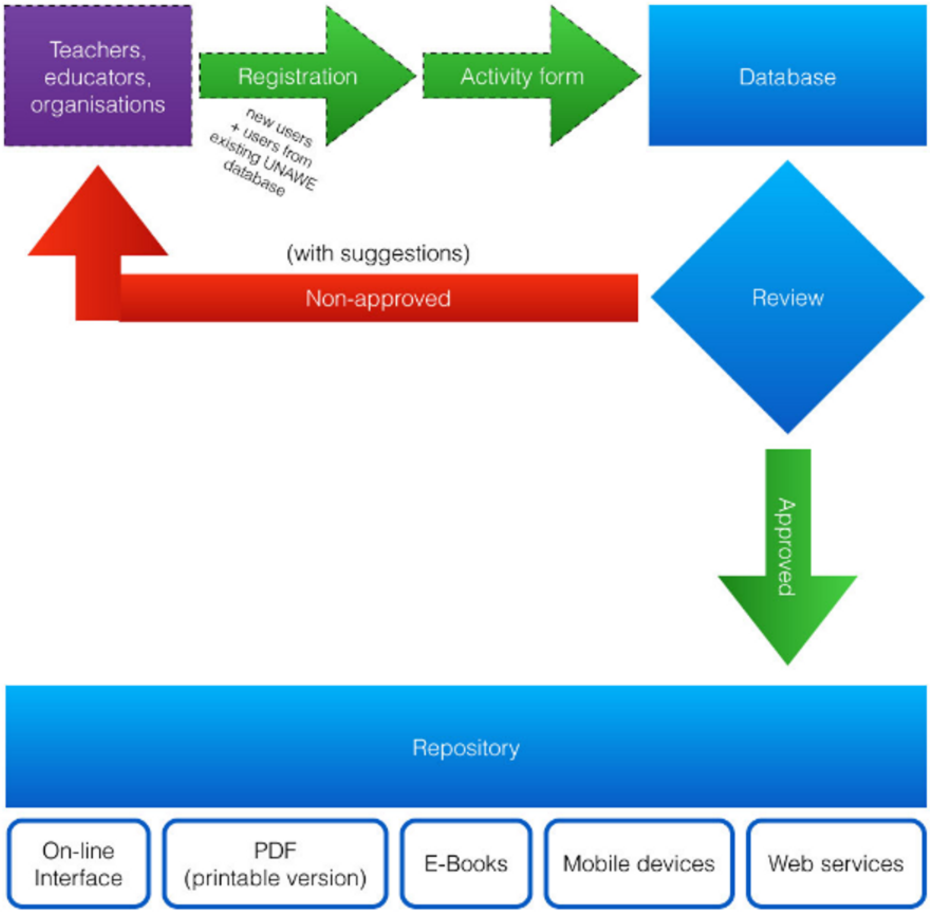


Figura 4.6: UNAWE' s process diagram.

The author that want submit a new educational activity to UNAWE has to register, completing a simple questionnaire as we can see in Figure 4.7. The registration permits to control various general information about platform's users which will be useful for the statistics, as the type of user who more utilises the platform, how often the platform is used, which country takes more advantage of it and so on. After the registration the author is able to insert the new activity in the database thanks to a simple form with fields to fill. The fields are exactly the same we have seen for the OERs in section 3.2.2. The structure model (Figure 3.2) is tested and considered extremely valid, thus it is used as principal structure for the activities also in the new repository. An example, extracted from the resource submission guidelines, is reported in Figure 4.8, instead for the full version see appendix D.

Once the completion of the form is finished, included any pictures or attachments, the system generates the source file, that often is a Rich Text Format

FIELD	M/O	DESCRIPTION
Name Surname	M	Full name
Language	M	Mother tongue
Location	O	Country of origin or/and of residence
Occupation	O	Educator, teacher, parent, student, etc.
Affiliation	O	Institution, fondation, school, programme, etc.
Email	M	Most used personal email

Figura 4.7: Registration's questionnaire.

(RTF) file. The source file is a file generated in a useful and simple format that allows to edit/correct/improve it without problems before exporting it in its final version, which includes different common formats.

The gathering of the material takes place in this part of the process and at this point the source files undergo the review process.

4.3.2 Review

Screening follows gathering and involves an assessment of the resource based on the type of content, language and learning design. Indeed, the value lies in simplicity, adaptability and transferability to diverse educational and organisational contexts [91].

The review process is supervised by a curator that like an editor is responsible to follow every stage to ensure the efficiency of the activity under every aspect. Before publication and dissemination there are three steps which involve three types of revision (Figure 4.9):

- Peer-review performed by one or more expert referees, similar to what happens in scientific journals, that is necessary to verify the quality and accuracy of the scientific content;
- Peer-review performed by one or more educators to verify the didactic feasibility and the pedagogical quality;
- Review performed by an editorial board to control writing and language style and correct them.

Curator/Editor

The curator is a person of the UNAWE' s team who supervises every aspects of activity's review. Sometimes, the curator can be an astronomer (scientist) or an

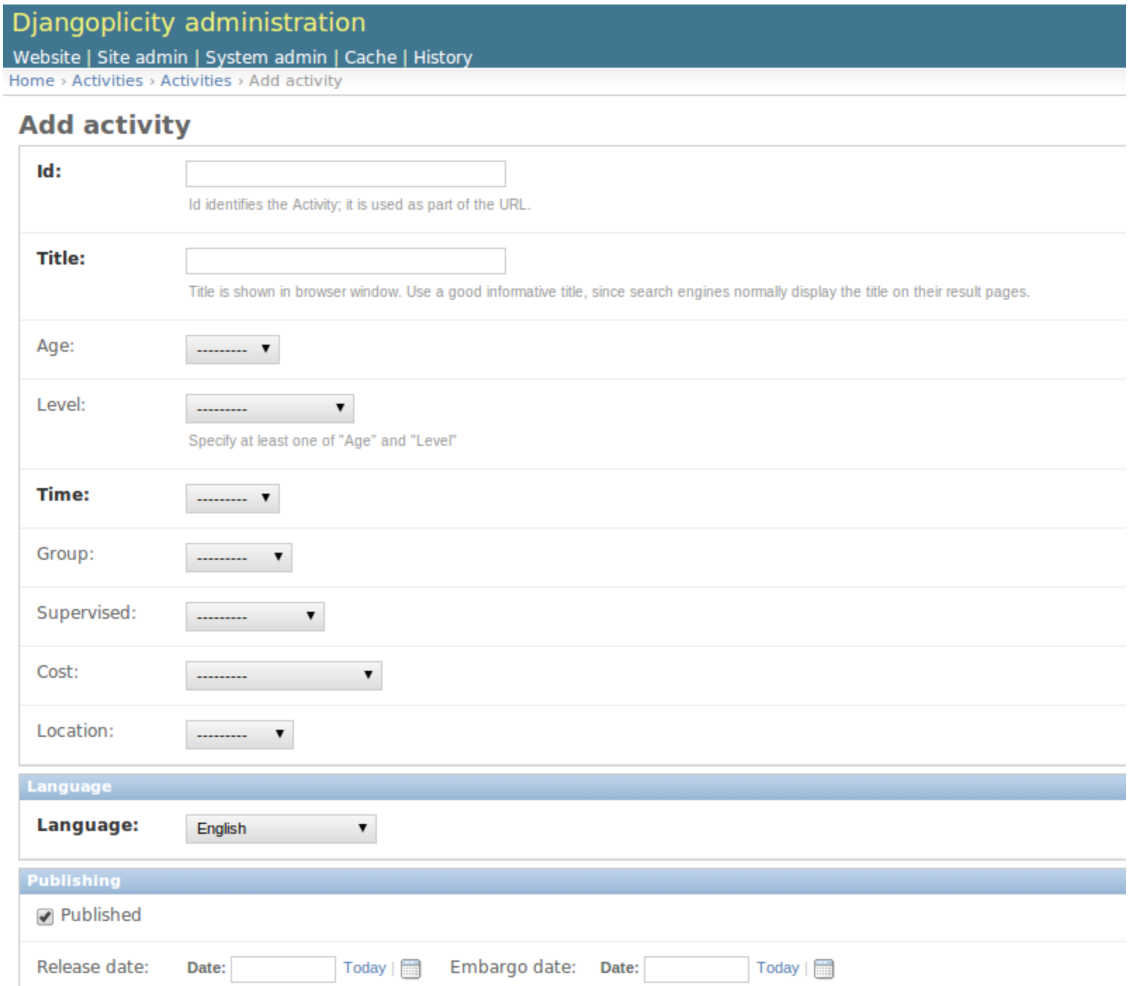


Figura 4.8: Example of submission page in the platform.

educator or part of the editorial board, being in this manner also directly involved in the other parts of the process.

However, the curator must also take care to verify that the material is legally clean, namely supplied by the appropriate licence. If necessary, the most suitable licence must be recommended to the author. Indeed, the licence has to guarantee the higher possible level of openness [88]. To be recognised a resource as free, a licence must grant the following freedoms [125]:

- The freedom to study and apply the information: the licence must not be restricted by clauses which limit the right to examine, alter or apply the information. The licence may not, for example, restrict reverse engineering (process of discovering the technological principles of a device/object or system through analysis of its structure, function and operation) and it

Figura 4.9: UNAWE's peer-review process diagram.

may not limit the application of knowledge gained from the work in any way.

- The freedom to redistribute copies: copies may be sold, swapped or given away for free, as part of a larger work, a collection or independently. There must be no limit on the amount of information that can be copied. There must also not be any limit on who can copy the information or on where the information can be copied.

- The freedom to distribute modified versions: in order to give everyone the ability to improve upon a work, the licence must not limit the freedom to distribute a modified version, as above, regardless of the intent and purpose of such modifications.

However, some restrictions may be applied to protect these essential freedoms, for example a licence can include a clause prohibiting commercial use of the resource by a third party.

For this purpose UNAWE uses the Creative Commons (CC) licences, these are usually used when an author wants to give people the right to share, use, and even build upon a work that they have created. A CC licence provides flexibility (for example, allowing only non-commercial uses of author's work) and protects the people who use or redistribute an author's work. In this way no-one has to worry about copyright infringement, as long as the conditions the author has specified are abided by [126].

Finally, the UNAWE' s activity can have no licence or Attribution-ShareAlike licence or Attribution-NonCommercial-ShareAlike licence (only for non-commercial purposes). The second one is the most used because it allows licences to copy, distribute, display and perform the work and make derivative works based on it only if they give the author the credits in the manner specified. Moreover, licences can also distribute derivative works under a licence identical to the licence that governs the original work [126].

At this point, the peer-review work is delegated by the curator to two or more experts in the respective fields of astronomy and education.

Scientific and Pedagogic Peer-review

Astronomer and educator (the referees or peer-reviewers) usually work together in a double review to verify that the materials are thoroughly enhanced from the scientific, pedagogical and technical points of view. They check that the content and the language are correct and appropriate scientifically and pedagogically. Furthermore, when possible, the referees fix and change the activity to satisfy the required standards. The transformation process occurs through [91]:

- Meshing: adding or replacing images, audio files, video files, tables or other attachments, where necessary, to make the content more engaging and also checking that embedded links are active.
- Sequencing: making changes, where necessary, to the order of the content for easy navigation.
- Scaffolding: suggesting changes to the content, to the language and to the style, where necessary, to ensure that learning goals and learning activities are properly aligned.

At the end of the double review, referees are asked to produce a report in free style and written in such a way as to help the final decision and the communication with the authors. Indeed, suggested changes to a resource should be clearly stated. Moreover, modified resources are usually resent to the referee for a final evaluation. This report should address the following issues:

- Originality of the resource and its potential interest for the audience;
- Alignment with the resource submission guidelines;
- Visual communication (make sure that schemes, graphs, etc) are clear and with the necessary quality;
- Language and content quality, if necessary;
- Balance between the length of a resource and its interest.

Basically, this process is essential to verify that the guideline to create the activity we have seen in chapter 3 is followed and, moreover, that the quality required standards are totally fulfilled.

Editing

The last part of the peer-review process consists in editing the resource, it also includes an assessment of the language used; for example, whether there is excessive use of jargon and whether the learning outcomes cannot be clearly understood. An editor from an editorial board checks for any obvious errors and desk-edits the resource [91]. In addition, where appropriate, the review process involves correcting typographical errors in the text and removing sections that made no sense in the absence of supplementary materials. This part of the process occurs through [91]:

- Decoupling: removing or amending elements of the teaching material not accessible in the public domain.
- Editing: for example, removing or explaining jargon and acronyms, and checking that all references provided are correct.

It is important don't forget that controlling quality by strictly enforcing pedagogical and production standards may make it more difficult for material to be reused in other contexts. Surely, openness of the resources enhances its usability [91]. This is why UNAWE provides a tried-and-tested model to ensure that OERs meet the quality requirements for reuse and re-purposing in other learning contexts.

After validation by the educator-scientist-editorial board team, the curator decides if the resource has to be rejected (providing a clear feedback why the resource should be rejected) or it must be before revised by the author or it is ready to be published and disseminated.

4.3.3 Publication and Dissemination

If the submitted resource is declared suitable after the entire peer-review process, it is published in the repository and it is ready for the dissemination. Indeed, the platform has products which enable wide and easy sharing in different formats and with using of different channels. This stage of the process relates not just to the technical formats in which the material may be made available, but also to whether the material is actually re-usable or re-adaptable in terms of size, visual appeal and discoverability.

In fact, the publication in the online interface (HTML format) allows to reach the resources in many different way. For example the activities can be downloaded in as many formats as possible to cater for the numerous ways of reusing and remixing them and to permit to use them with different devices. We name a few: PowerPoint presentations for computers (desktops, laptops) or mobile devices (smart-phones, tablets, iPhone, iPad); PDF, DOC and ODT files for computers and printable, EPUB and MOBI files for e-book readers and so on. Moreover, platform should use, as a one of distribution channels, a dedicated mobile app and web services like search engines, other platforms and social networks.

Furthermore, remembering that when looking information, the search engines are the best, we emphasise in the fact that the repository must be optimised to make searches using any search engine. It doesn't matter which engine is used because most of the search engines use very similar algorithms for their search [127]. Don't forget that this must be true also inside the platform's site. Indeed, another important point is that learning resources need to be searchable across the repository. Therefore, general information about the resource are necessary to use filtering techniques. The information that help to search and find the resource are title, language and keywords, as well as life-cycle information, meta-data, technical information, educational information and pedagogical characterisation of the resource, information regarding copyright and more [88].

In addition, the platform must support also the finding of most interesting resources through conversations, recommendations and cross-linking of resources in social networks, services based on Rich Site Summary (RSS) feeds [9], which are continually updated websites, as well as personal libraries of end-users with information about and links to thematically relevant content [88].

Basically, the things to consider while designing the platform website are multiple and the improvement of usability of the user interface is a key principle of web accessibility. Indeed, it is necessary to design websites and software that are flexible enough to meet different user needs, preferences and situations. This also increases usability of websites in situations with low bandwidth (images are slow to download); noisy environments (difficult to hear the audio); screen glare (difficult to see the screen); driving (when eyes and hands are busy). Other illustrations of accessible web design are redundant text, audio and video which can support different learning styles, low literacy levels and different language access. Additionally, style sheets can support more efficient page transmission and site maintenance [88].

In light of all this, during the creation of the website, UNAWE has focused on three fundamental aspects that involve the web site and page design [129] [130] [127] [131]:

- **Search Engine Optimisation Basics**: for the placement in search engines, it is the words that count, so keywords placement really matters. For example, important keywords should go in a HTML page's title and headers. When using meta tags, meta information, the page provides a description and keywords for telling a search engine what the web site and pages are all about. Efficiently meta tags, limited to a dozen or so terms,

[9]Documents which include full or summarised text, plus meta-data such as publishing dates and authorship. They are used to publish frequently updated works—such as blog entries, news headlines, audio and video—in a standardised format [128].

include technical description of the kind of content on a page. For the users there must be a clear and naturally flowing hierarchy inside the page, which could be done with the creation of two site-map: one for users, one for search engines.

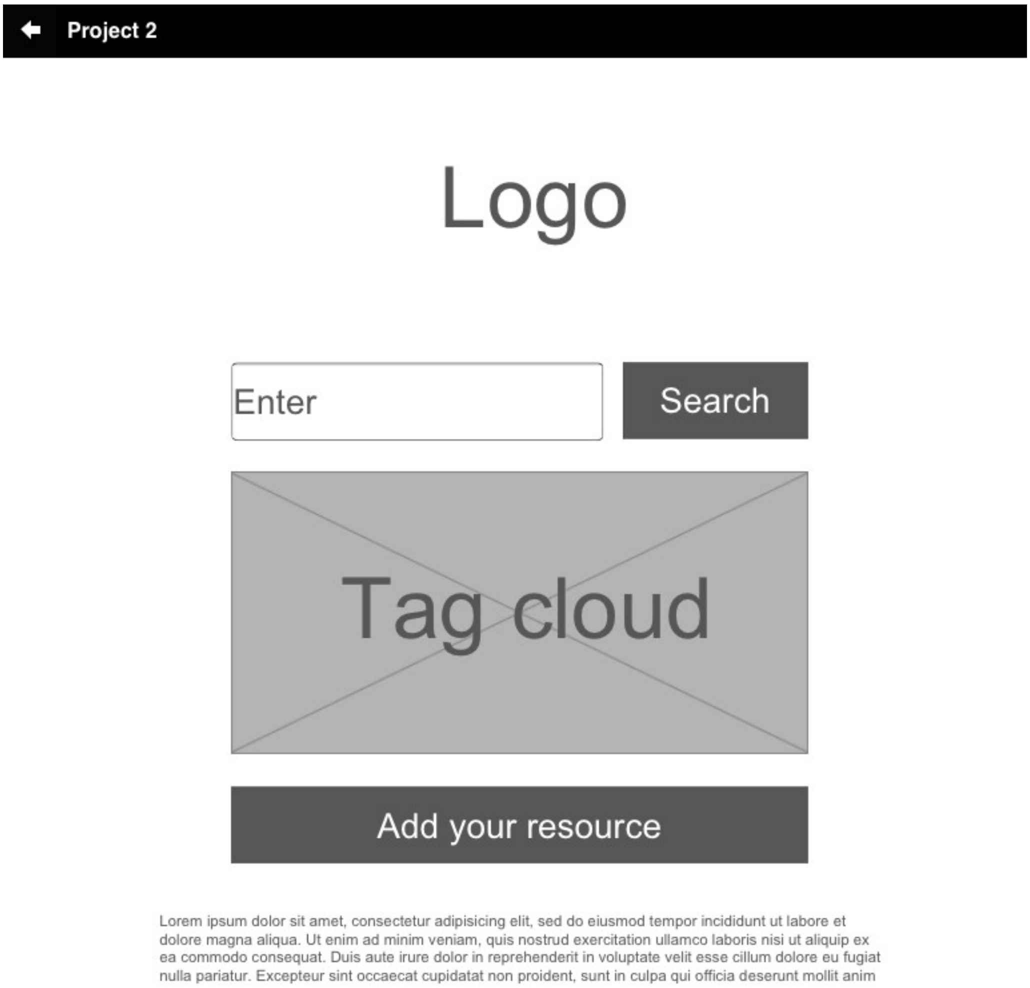
- **Optimising Content**: writing an accurate and clear anchor text, the clickable text that users will see as a result of a link, helps users and the search engine itself. The files also should be put in specialised directories and divided by common file formats, specifying the file extension on the file name. All the media contents should have accurate text attributes on the page.

- **Improving Site Structure**: due to the Uniform Resource Locators (URLs) [10] are displayed in search results, a simple directory structure should be used, so the use of words, related with the content, in URLs is better for users and search engines. The links that relate the site with the search engine, inside the site and with other pages must be working, so it is necessary not to have broken links.Since, in search engines, algorithm and methods of research keep changing very fast, the repository must be changed frequently, considering also in the way it interacts with users and search engines as well.

A platform with a mapping tool ensures consistency between material and how is accessed. Indeed, complete information, not extensive, provides guidance on the structure of the content and an efficient search to people without previous knowledge on the topic [108].

In conclusion, the website that houses the new platform is designed to satisfy all these requirements and we can see some examples of home page and resource page in Figures 4.10 4.11 4.12. Actually, this part of the process is in phase of testing yet, but soon the platform will be ready to be operative and functioning.

[10] Also known as web address, it is a specific character string that constitutes a reference to a resource [132].


Project 2
Logo
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Project 2
Platform logo
Title
Keywords
Short description
Language
Age sugestion
Time
Cost of materials
Individual / grups
Indoor / Outdoor
Source
Related resoureces
Learning outcomes
Description
Science backgroud
Download options
PDF
Source file
RTF
E-books
Instruction
Step
Step
Step

Figura 4.12: Example of resource page from the platform.

4.4 Language and Culture

As we have seen in section 4.2, the resources can be submitted in each of the languages of the reviewers. When a resource is published in the platform, if successful, it will be translated into every attainable languages. This obviously implies not only a language problem for literal translation but also a cultural problem, because the activities can arrive from every country in which UNAWE has an active programme and they are definitely influenced by the local culture.

In this purpose, we have to consider that to improve teaching and learning for children, from both dominant and non-dominant backgrounds, we must delve more deeply into understanding learning and development as fundamentally cultural processes. In addition, central to the future of science and science education is to understand, support and leverage the ways in which diversity (of people, practices, languages, meaning, knowing, epistemologies, goals, values and the like) in learning environments is an asset. This, consequently, expands the possibilities for human knowing and meaning [133].
Indeed, an increasingly influential framework proposes that, although the construct of culture is problematic, people nonetheless live culturally. The understanding of culture implies that there is no culture-less or neutral perspective. In this sense, everything is cultured, including the ways schools are organised and education is implemented, layout of museums, scientific practices, and the practices associated with teaching science in school [133]. Therefore, the developers of resources can not underestimate these aspects.

To confirm these ideas, a report from an online discussion on OER, organised by the UNESCO International Institute for Educational Planning, concluded that OER are cultural as much as educational, in that they give users an insight into culture-specific methods and approaches to teaching and learning [134].

Even if a number of projects now exist in developing countries to develop OER based on their own languages and cultures, nonetheless, at the present time, the vast majority of OERs are in English and tend to be based on Western culture. This limits the relevance of the materials for non-English and non-Western settings. Moreover, there is a risk that language barriers and cultural differences may consign less developed countries to the role of consumers of OER rather than contributors to the expansion of knowledge. Concern is also voiced by the fact that institutions in developing countries might become dependent on externally generated content, rather than have the content serve as a catalyst for the production of new and local OER [88].
Furthermore, it's not possible to overlook the cultural problem because the conditions under which OER are created, the languages used and the teaching methodologies employed result in products that are grounded in and specific to the culture and educational norms of their developers. These may be remote from the understandings of other cultures and lead to dysfunctional education and a

reduced potential for developing countries to contribute research, training, experience and understanding that invigorates the value and scope of OER [134].

Besides all, the language translation offers a partial solution to this problem. Partial because if the full benefits of these OERs are to be realised, it is necessary to have a real capacity for the adaptation of language to the needs and modes of understanding of local contexts. Indeed, localising OER is not only a question of language but above all one of culture [88].

In this vision, some words simply can't be directly translated. In fact, sometimes a basic concept requires an entire sentence in a another language just to convey the original intention from the first language. Furthermore, the words can denote an incredible array of meanings that only context can provide. Therefore, it's impossible to directly translate every word or phrase. It is necessary to rely on what's called transliteration, which is an approximate rendition of the original language to the target language. The difference is not with language itself, but the manner in which language is used. Moreover, a direct transfer is not only impossible but frequently wrong, thus simply translating important elements won't be enough [135].

Ultimately, it is important to be aware of cultural and pedagogical differences between the original context of use and the intended new use of the material. In addition, we have to remember that translators are not necessarily scientists or educators and may not have the background needed to contribute new content effectively [88].

In its multilingual platform that supports knowledge sharing between different parts of the world, UNAWE replies to the problem, developing partnerships with local academics and institutions to embed volunteer translators in member countries. In this way, the translators are not only experts in astronomy and pedagogy, but also aware of the cultural aspect of their country. They can transmit the concepts with the right values and adapt the activities in particular for their environment.
This allows a wide distribution of resources, but does not affect the quality. Moreover, thanks to this work, UNAWE aims to achieve to meet the 5 Rs network (section 4.2) at a global level.

In effect, UNAWE recognises the importance of considering local cultures, uses local experts and supports the activities that are performed in each partner country. Since the local experts understand the local cultural needs and histories, they succeed to develop, improve and implement the activities. In addition, if ideas are contributed by educators close to the children, the resources convey the right message, children identify with the characters featured in the stories and they are familiar with the real-life examples shown [46]. Therefore, it is very important to consider the impact that local cultures play in educating young children. There is evidence that education programmes that aren't responsive to local cultures will suffer from lower levels of enrolment and retention [136].

It is necessary at this point to expand the vision, namely that the cultural problem not only deeply influences the translation of the activities, but also affects the design and the structure of the website. Indeed, developing online media for a specific global audience requires more than adapting currency formats, time zones and translation. In fact, when designing a global website it is never easy consider all the cultural aspects. This is because there are very different types of cultures, with different values, different ways of thinking, different visions of what is important and what is not. The culture influences humans since they are children, it grows up with people for a lifetime. For this reason culture is strongly rooted in each of us. Indeed, through culture, people give meaning to the world [135].

There are, for example, some aspects that strongly affect the creation of websites and unfortunately they are seen in opposite ways by different cultures. It is therefore difficult, if not impossible, to find a solution that is globally accepted. Some of the most important aspects are [135]:

- Uncertainty: degree of effort in the attempt to elude unknown situations.
- Communication Context: use of a high or low level of context in exchanging information.
- Social Fabric: vision of social relationships in individualistic or collective way.
- Time: time perception according to the clock or according to the needs of people.

These aspects can be put into effect through the presence or absence of: use of historical context, excessive use of detailed descriptions or metaphors, need to give users what they want in as few steps as possible, use of a more elaborate font of writing, use of certain colours rather than others, use of particular stylistic effects, abundance of pictures and videos.
Of course all this is reflected in the architecture of the website, which includes systems to organise, label, structure, search and consult the information. In practice, this affects the multimedia contents and the interface. Moreover, particular attention should therefore be given to the meta-data, because they are widely used in all of these systems and are based on the use of appropriate words to describe the web page. As a result, the adaptation of meta-data to the used languages becomes essential and this, we have seen, means far more than simple translation [135].

In this scenario we underline the fact that UNAWE' s activities are tailored to young children. This factor slightly simplifies the cultural problem (especially for the website, with fascinating images, drawings and colours children are easily captured), but there's no denying that educating young children about astronomy is challenging, especially in a global project that needs to consider many different local cultures.

But at the same time, in this ever-shrinking world, children are certain to grow up into situations and jobs that require them to communicate alongside colleagues from all corners of the globe. This makes it imperative that they consider themselves part of a global community. Furthermore, it is important that they are introduced to different languages and cultures from the youngest possible age [46].

The fact to keep in mind the cultural aspects during the translation of the activities and the development of the platform is extremely innovative in the field of educational resources for young children, moreover, so far in this sector it has never been addressed on a global scale. UNAWE is the first international educational programme of this type that tries to involve the cultural aspect as a fundamental component of educational activities development.

4.5 Useful Tools

UNAWE has provided its Peer-Review Platform and the activities with tools to guide and support the users, including question sets, review of materials and access to other high-quality materials that address the same topics. In addition, in the next future, there is the idea to implement each resource also with a step-to-step video on how to carry the activity out.

Since, as we know, the educational resources have a dynamic life cycle, we want to suggest that it would also be helpful insert tools to allow users to annotate and comment the resources, in order to promote a collaborative process for their evaluation and facilitate in this way their management [121]. For instance, we find that tools like help buttons, assessments with feedback and multiple ways of explaining critical issues are interesting. Communication tools (such as forums or blogs) to enable learners, interested in the same subject, to communicate are also fascinating [92]. In the future, maybe, it could be possible to insert a space dedicated to teachers. This space can allow them to ask for creating activities about particularly difficult or missing topics, to ask questions on how to face some subjects or on which are the best activities to explain certain arguments.

From an even more futuristic point of view, we hope that the UNAWE' s platform will become a wiki, that is a website which allows people to add, modify or delete the content via a web browser. Some wikis permit control over different functions and levels of access. For example, editing rights may permit changing, adding or removing material. Others may permit access without enforcing access control. Other rules may also be imposed to organise content [137]. In this manner people from all over the world could continually review and update the content (Figure 4.13). One of the most famous wiki is the peer-produced encyclopedia Wikipedia that has now over 4.2 million articles in the English version and has versions in over 270 other languages [138].

Nevertheless there is much time to take care of these aspects and surely the new platform will unfold and will evolve to satisfy ever-changing needs.

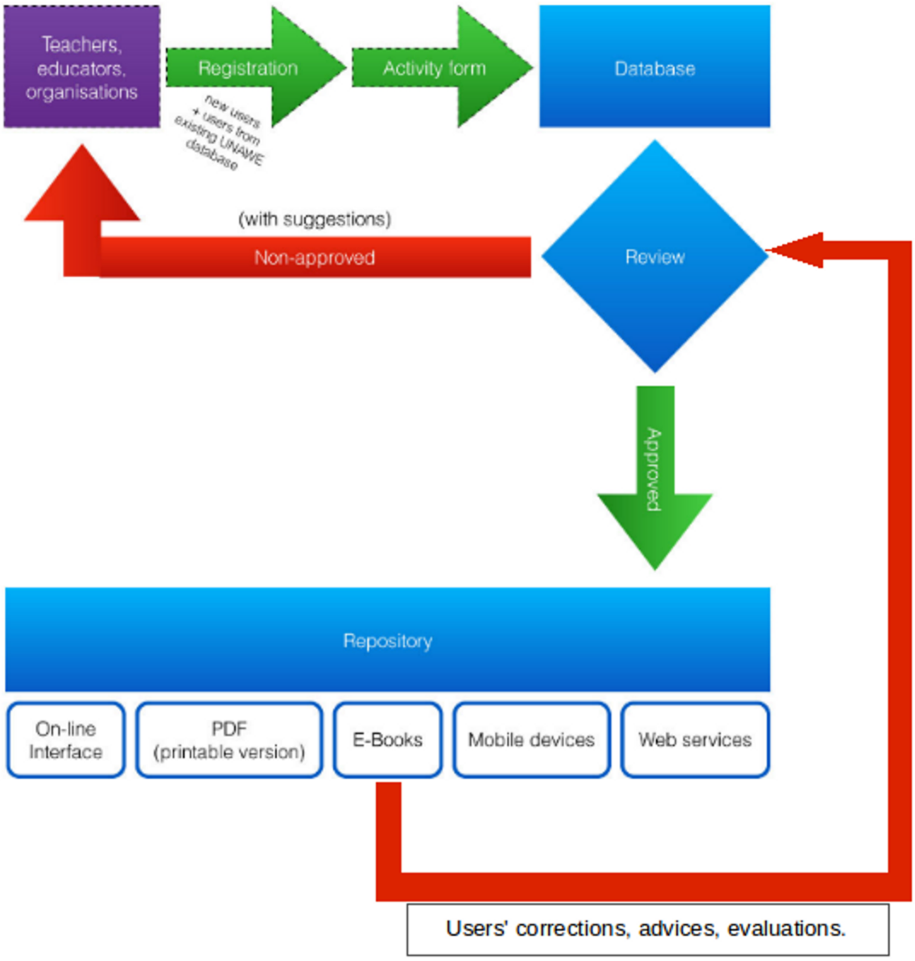


Figura 4.13: Process diagram for the UNAWE' s Peer-Review Platform as wiki.

Conclusions

Openness has become a defining feature of twenty-first-century education and OERs are rapidly becoming a necessary hinge that enable the paradigm shift towards openness. Despite their growing popularity, OERs raise many questions regarding quality, searchability, policy, pedagogy, rights and technology [91].

In the field of astronomy there are too many resources and too many repositories for these resources, which make complicated how to find the most relevant resources, how to know their quality and to keep them up to date. Moreover the repositories accredited by a recognised institution (for example NASA), which guarantees the quality, are only three and soon they'll be two. In addition, none of those satisfies completely the 4 Rs framework (Reuse, Revise, Remix and Redistribute). A this point the best alternative for a search of online information is the search engine, but the resources' quality still remains unknown. Unfortunately, the use of meta-data and filtering systems are not enough to solve the problem.

In reply to all this, UNAWE proposes the new Peer-Review Platform for Astronomy Educational Material that satisfies not only 4 Rs but 5 Rs, adding the phase of Review, inspired by the peer-review process in scientific research. With this platform, UNAWE aims to solve for its OERs the quality and usability problems. Indeed, every astronomical activity submitted to UNAWE (written in any partner country language) undergoes the peer-review process carried out by the astronomer-educator-editorial board team, with the supervision of a curator. In addition, it receives accreditation by the IAU Office of Astronomy for Development and the application of an appropriate Creative Commons licence. Moreover, if the activity is judged efficient, it is published in the repository and made available in many different formats. These formats can be utilised with several devices: from printed paper copies to mobile phone or computer. Also the visibility and usability of the platform is taken into account. The platform is adjusted to solve these needs using Search Engine Optimisation methods, organising the content, improving the anchor text and site structure.

Besides, the successful activities will be translated in every available language and at this purpose, UNAWE exploits the collaboration of local experts. At this point, UNAWE has to face off linguistic and cultural problems, because we cannot separate language and culture. Compounding this problem, the fact that the majority of producers of resources and OER projects seem to be in English-speaking countries in the developed world. Unfortunately, the simple translation of the resource is not enough, culture plays an important role in this. Indeed, sometimes to convey a basic concept requires an entire sentence in a another language and usually words can denote an incredible array of meanings that only context can provide. The key lies in the manner in which language is used and in citing cultural aspects which belong to the place. Furthermore, the cultural aspects influence also the website structure. However, being the final target audience young children, it is more simple capture their attention.

In addition, as we know, UNAWE' s platform already uses helpful tools to support users, in particular teachers. Like question sets, review of material, presence of external links, etc. Many more tools are also available and we suggest to improve them with time. For instance tools that allow to comment and evaluate resources, help and feedback buttons, forum, blogs and so on, up to maybe become a wiki in the future.

Making operative the new Peer-Review Platform will take a lot of commitment, people, efforts and work. And for all this, time is necessary. In this moment, UNAWE' s repository is in the testing phase: all the existing resources have undergone the peer-review process and they are published in the repository. The evaluation is now starting, a new stage for the realisation of the project. Not only the platform is under evaluation, but also the activities. It is important to verify directly the quality and if goals are achieved. Moreover, in case of negative feedback it is imperative to intervene to improve resources. Meeting the goals of an OER project is fundamental to avoid any risk of spending years producing and sharing resources that teachers and learners are unable to use [88]. Indeed, the value of an integrated competence-based network lies not simply in its suitability for transforming existing teaching materials into OER, but, more importantly, in its use of evaluation methods for assessing the quality, ease of access, adaptability of OER and the potential impact of OER on teaching and learning [91].

Evaluation and assessment are discussed more in detail in the next chapter.

Capitolo 5

The Evaluation Programme

There are various ways to make evaluation and assessments of an educational project. These involve several judging levels from which different helpful estimates can be draw. In literature, we find many examples, tips and guidelines on how to develop an evaluation plan. In this chapter we analyse the evaluation process. We also discuss the fact that an evaluation is being performed at UNAWE, that is based on the guidelines available in the literature, in order to perform an accurate and reliable assessment of the activities. Finally, we suggest how to face some issues and some ideas to perform also an impact evaluation in the future.

5.1 Definition of Evaluation

A considerable amount of time, effort and resources go into the development and implementation of education projects as UNAWE. Quite obviously, the goal is to create effective projects that can serve as models of excellence [139]. Moreover, being the education projects developed because participants gain specific knowledge and skills, a careful attention to the design and implementation of an education project will be reflected in learner outcomes. This is why the effective evaluation of educational projects is becoming more important for funding and the organisations involved in the projects.

Exploring the meaning of word *evaluation*, it results that evaluation generally means to appraise or ascertain the value of something. Basically, evaluation helps to know if the project successfully reaches the goals it sets out to achieve. In effect, project evaluation serves principally two general purposes. It helps to determine the project's merit (does it work?) and its worth (do we need it?). Furthermore, evaluation helps decision-makers determine if a project should be continued and, if so, suggests ways to improve it and to make it more effective or successful [140]. The reason of this revolves around the desire to understand, in a systematic way, what is and is not working in a project [139]. In addition, evaluation can serve to document unexpected or unintended outcomes. Indeed, by taking a systematic approach to project evaluation, we can improve the effectiveness and credibility of our projects [140]. From the OECD glossary's definition [141], evaluation is the systematic and objective assessment of an on-going or completed project, programme or policy its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of lessons learned into the decision making process. In conclusion of this exploration, evaluation is technically the systematic collection of information about activities, characteristics and outcomes of projects to make judgements about the project, improve effectiveness and/or inform decisions about future programming [139]. Therefore, project development requires a commitment to a systematic, iterative process of assessment, design, implementation and evaluation.

Ultimately, evaluations contribute to secure the optimal quality and impact of development interventions and they also help managers of projects and programmes to manage and improve their implementation. Above all, evaluation is an important feedback mechanism for the education projects and must be a their integral element. Indeed, the main purpose of an evaluation is to determine whether the project goals have been met.

5.1.1 Goals and Outcomes to Consider

The evaluation is strictly related to the project's goals and to the necessary means to reach these goals. Therefore, it is important for an objective assessment to make explicit all of the goals that will be evaluated. Nevertheless, often, there are implicit goals to consider. For example the improvement of participant's attitude toward (in this case) the astronomy. Basically, during an evaluation there are two main types of goals to assess [140]:

- *affective goals* aimed at enhancing participants' attitudes, values and interests in science [1];

- *cognitive goals* designed to increase participants' knowledge of science concepts or to improve their scientific enquiry skills (they focus on what participants understand and can apply).

It is important to underline that the evaluation of an educational project has furthermore to consider several project's aspects. In effect, to ensure that evaluation is carried out in the best way possible, the evaluation team must carefully consider all of them [139]:

[1] In the language of education, *attitudes* are the extent to which participants like or enjoy something, *values* are the degrees to which participants think that something is important to engage in and participants' *interests* are things worthy of allocating time to [140]

- Inputs: List the time, money, human resources, office space, utilities, equipment, supplies, management and partner support, etc. needed to accomplish the project.
- Outputs: Describe the activities, events, products, and services that reach people targeted by the project.
- Short-Term Outcomes: Describe the expected immediate impacts of the project (e.g., audience reactions and changes in knowledge, attitudes, skills, or aspirations immediately following participation in the project).
- Intermediate Outcomes: Describe expected impacts (2-3 years) on the audience's behaviour because of the project. These outcomes tend to occur after there has been an earlier change of knowledge, attitudes, skills, or aspirations.
- Long-Term Outcomes: Describe the intended ultimate impacts (4-10 or more years) of the project on the issue. These might be social, economic, or environmental conditions. These consequences are expected to occur after a certain number of behavioural changes have been made.

It is also important that evaluations are carried out either during the project cycle and at the end of a project or programme [142]. Namely that there are several different types of evaluation to consider. Depending on the stage of project planning, managers may conduct a needs assessment, formative evaluation or summative evaluation.

5.1.2 Different Types of Evaluation

From the literature we can extract three main types of evaluation [139] [140]:

- **Front-End Evaluation or Needs Assessment**
  It is a systematic study of the needs of the programme and its potential consumers, may be included as part of the planning evaluation. It usually takes place prior to undertaking the project. Gathers information/data about the gap between the current and desired level of audience skills, knowledge, attitudes and behaviours. Helps confirm or negate assumptions of audience characteristics and appropriate content, define goals and identify stakeholders and potential collaborators.
- **Formative evaluation**
  It assesses a project while in progress, making suggestions for change and further evaluating any mid-project alterations that are implemented. Therefore it is conducted throughout the project, during project design, development and implementation. Most often, formative evaluation is used to test out methods and materials. Gathers information/data about an audience's reaction to and learning from products/materials. Furthermore,

gathers information/data about problems with project delivery and assesses progress towards outcomes of a project during implementation. Helps provide information that can be used in making decisions about modification, continuation or expansion of the project.

- **Summative Evaluation**
  It looks at a project only upon its completion. This is performed with the intent of making a final judgement about the level of success of the project. For example, by determining if its goals and objectives were met. Results are collected in a final formal report and it is used to inform stakeholders and decision-makers about the value or worth of the project. Gathers information/data about the audience's skills, knowledge, attitudes, and behaviours at some point in time after project implementation begins. Helps provide the information necessary to make decisions about the continuation, revision or expansion of the project.

Furthermore, to evaluate a science education project, it's helpful to have clear the standards which have to be achieved and the purpose is assess the achievement of those standards by students. Indeed, the standards make clear what information will be accepted as evidence that students have achieved them. The standards should also include a description of the performance expectations for students in clear and specific terms. In this purpose, it is useful to include circumstances to assess students progress during and after the activity as we have already suggested in section 3.2. In addition, it is more effective to use multiple modes of assessment to obtain the kinds of information that are needed to understand and effectively monitor students' science learning [143].

At this point it is clear that an evaluation programme, covering each type of evaluation we have seen and meeting all the necessary criteria, is important for the success and survival of educational projects as UNAWE.

5.2 Relate Goals, Outcomes, Evaluations to Data Gathering

The considered type of evaluation (i.e., front-end, formative or summative) will determine, to some extent, the most appropriate data collection tool(s). Indeed, evaluators have an array of data collection methods available to them. Likewise, the conducted level of evaluation (e.g., learning, application, results), the audiences involved (e.g., children, adults, casual visitors) and the amount of resources available (e.g., time, money) will all help determine which tools should be used. However, every data collection strategy comes with strengths and weaknesses [139].

Project evaluation, like educational research in general, can encompass a variety of quantitative and qualitative data collection strategies. Basically, systematic qualitative methods might include, but are not limited to, repeated classroom observations, collections of participant's work or interviews of which allow us to record explanations, perceptions and descriptions of experiences. Qualitative methods allow us to create narratives that provide an in-depth view and a more complete understanding of the context of the evaluation. However, this is usually insufficient for making wide generalisations that can be applied to other projects [140]. On the other hand, quantitative methods, for example surveys, allow us to perform statistical analysis and perhaps wider generalisations beyond the actual respondents to the relevant population [140]. Remember that since data gathering tools are developed for a specific purpose and project, they rarely represent a pure form. For example, a survey or interview may include test items. A case study often incorporates observation, document review and in-depth interviews [139]. For a complete list of data collection instruments see appendix E.

Thus, the most useful evaluation studies use a combination of quantitative and qualitative data gathering. In particular, results obtained from quantitative instruments need to be validated qualitatively, using individual or group interviews [140]. Consequently, used in combination, the individual strengths of quantitative and qualitative methods can be maximized and the weaknesses minimized.

Moreover, every different kind of evaluation involves different outcomes and can chose different data gathering methods. To better understand, it is helpful analyse more in detail the short-term, medium-term and long-term evaluations.

The Short-Term Evaluation

The short-term evaluation is split into two levels and these levels are part of formative evaluation [139] [140]:

Level 1. Reaction

Reaction evaluation measures the audiences' immediate positive or negative response to the activities or learning experiences. This is the most common level of evaluation. Often referred to as smile sheets, these evaluations ask participants to rate their perceptions and their feelings about the quality and impact of the specific project or activity. Indeed, smile sheets can range from a handful of questions (regarding the project delivery, facility and usefulness), to pre and post test scale surveys and forms that ask participants to rate all aspects of the activity. Therefore, reaction evaluations are an important tool to measure participants' satisfaction. Indeed, they belong to the affective domain. Moreover, by letting users rate or comment on the resource or describe how they have used it we can select high quality, useful or good in any other respect resources. Another important factor is that these types of evaluation are relatively easy to administer, tabulate and summarise in a results report.

Level 2. Learning

Learning evaluation measures whether participating in the project increases the audience's knowledge and awareness of the issues addressed. A number of different tools can be designed to measure what project participants have learned. Before and after tests, simulations or demonstrations and other in-class (observable or measurable) methods allow instructors or project designers to determine if the knowledge or skills identified in the objectives were learned. Indeed, this evaluation belongs to the cognitive domain. However, these evaluations do not measure long-term knowledge or skill retention, nor are they an indication of how these will be applied to a real-world situation. Moreover, learning evaluations are more difficult to design and administer than reaction evaluations. One reason is that they must be customised for every instructional activity or project.

These kinds of evaluations are carried out in the initial part of the project or for new activities involved in the project in a second time. The initial part of a project extends to its first one year and half or two. Therefore, every evaluation conducted in this period, after the performed activities, is included in the short-term evaluations. An example can be an interview with reached students who one year previously performed an activities. During the interviews, the students will be asked to talk about what they remembered from their experience. Afterwards, interviews will be transcribed and analysed to identify emergent themes identified by the students. Such as action, knowledge and attitude themes.
Obviously, it is important that all these products be thoroughly evaluated (including classroom testing) to judge their ease of use, appropriateness, value and effectiveness before they are widely disseminated. Furthermore, a valuable goal of these evaluations is that their results can be used to modify the activities and performing methods to better meet the programme goals.

The Medium-Term Evaluation

The medium-term evaluation can be part of formative or summative evaluations [139] [140]:
Level 3. Behaviour or Application
Application evaluation measures if the participant has been able to use the new knowledge and skills learned. Application evaluation is significantly more complex than the first two levels in that it requires contacting participants after they have had time to apply the new knowledge and skills. As with other evaluation levels, many different tools can be used to collect the data. Tools include surveys, interviews, focus groups, observations and written document review. In addition, regardless of the tool, the questions should present specific skill and knowledge areas and ask participants if and how they have applied them since learning them. It is important to know not only that participants understood the material during the learning experience, but that they are then able to go back to their homes, communities or jobs and apply it. This level of evaluation provides evidence of whether transfer of learning has occurred and it more deeply belongs

to the cognitive domain.

This part of project's evaluation extends from two to three years after the performed activities. Thanks to this longer period of observation and gathering data, we can also find any indications about the real value of the activities (affective domain). For instance by showing the number of downloads for each resource on the website or considering the collected comments about them during the time. Therefore, it is important understand that summative evaluations have their own place in improving education and outreach efforts, though their intrinsic value may not be as obvious as that of formative evaluation.

The Long-Term Evaluation

The long-term evaluation is part of summative evaluation [139] [140]:
Level 4. Results Results evaluation measures the degree to which any behavioural changes have impacted on the environment or audience's lives. In order to actually conclude that a project has had its desired effect, participants have to successfully apply the new skills or knowledge. That is, the application of new skills and knowledge leads to the desired result or impact on an audience or the environment. This is the final stage of the evaluation process. Such feedback is useful for making the business case regarding, for instance, the impact of OER on teaching and learning and for future development and improvement of the project sustainability. At this point it is necessary to use web based applications, such as Google Analytics, which track access to the repository from global sources and provide information on the number of visits and pages viewed from different geographical locations [144]. The implementation of an optional questionnaire at the point of download, to be completed by users, is also an interesting idea to assess the value and usefulness of the resource [91]. In this way the mechanism gathers both quantitative and qualitative evidence on resources use, to enable us to gather information about the context and what difference a resource made. Basically, this level of evaluation belongs to both cognitive and affective domains. It is important underline that in this phase of the evaluation, questions regarding cross-cutting issues (poverty, gender, environment) are integral part of the summative evaluation. For example, evaluation of cross-cutting issues can involves [142]:

- Assessment of the project with regard to poverty reduction and Millennium Development Goals (MDGs): to what extent the project contributes to poverty reduction as well as to the achievement of the MDGs.
- Assessment of the project with regard to the promotion of gender equality: the extent to which the project contributes to the promotion of gender equality.
- Assessment of the project with regard to the promotion of the environment: the extent to which the project has positive effects on the environment.

The collection of longitudinal data (tracking participants years after their initial involvement in a project) is one of the most valuable and most difficult of all evaluation tasks. Indeed, this part of project's evaluation extends from four to ten or more years after the performed activities. This level of long-term feedback is becoming increasingly important particularly when priorities are being set or when decisions to continue or discontinue the project are being made. Results evaluations are typically feasible only for large scale projects designed to produce specific results for a specific audience. Furthermore, knowing the influence of a project down the road (what is known as an impact evaluation) can be beneficial for similar or extension projects of the future.

In conclusion, the decisive factor for the success of every evaluation is the implementation of all the recommendations we have seen in this chapter until now, as otherwise evaluations are useless. It needs moreover to be clarified by whom and how the evaluation results will be utilised. The management response needs to be revised at least once a year in order to see to what extent the recommendations have already been implemented. Pursuing and implementing evaluation results is essential for good development of every educational project [142].

5.3 Planning and Realising a Successful Evaluation Programme

This section is inspired and in part extracted by the *UNAWE Programme Evaluation Guide* [145], *Guideline for Project and Programme Evaluations* [142], *Finding the forest Amid the Trees: Tools for Evaluating Astronomy Education and Public Outreach Projects* [140] and *Designing Education Projects* [139].

As mentioned earlier, evaluation is the systematic collection of information about activities, characteristics and outcomes of projects to make judgements about the project, improve effectiveness and/or inform decisions about future programming. Therefore, great care must be made in the planning of any evaluation. In light of this UNAWE has meticulously planned an evaluation process that covers nearly all types of evaluation we have seen and that , moreover, leaves room for future implementations and improvements. We underline the fact that the first type of evaluation to do is the Needs Assessment, as we have seen in section 5.1.2. In addition, during the project planning and as result of this Needs Assessment, project planners often find the development of a project's logic model (Figure 5.1) particularly helpful. The project logic model should help to establish the goals and objectives of the future evaluation. Consequently, the logic model illustrates the relationships among the various project components (initial situation, identified priorities, inputs, outputs, short-term, medium-term and long-term outcomes). Basically, logic models provide a roadmap, showing how the project is expected to work, the logical order of activities and how the

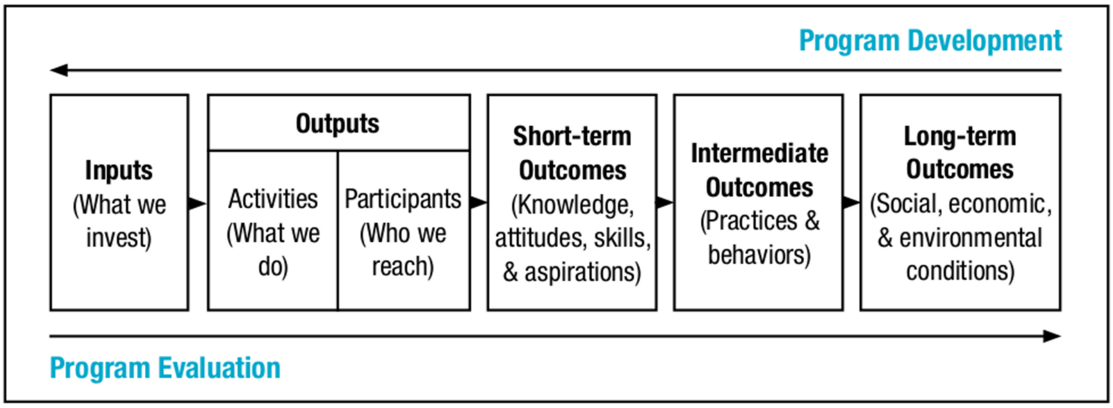


Figura 5.1: Project Logic Model.

desired outcomes will be achieved. We can see an example of logic model in Figure 5.2. As result, after the develop of this logic model, UNAWE created the

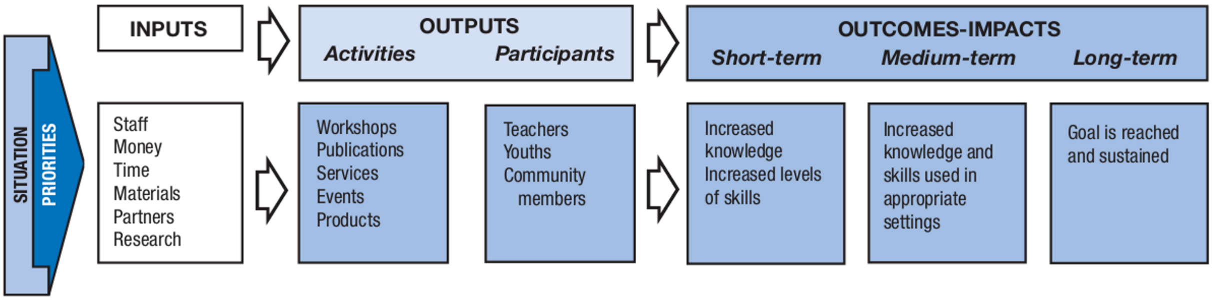


Figura 5.2: Example of logic model. Source: Adapted from Taylor-Powell, E. and Jones, L. & Henert, E. *Enhancing Programme Performance with Logic Models*, 2003.

evaluation matrix, aligning directly goals with measurable outcomes. Actually, UNAWE created two evaluation matrices, one for each of its different types of audience: children and teachers (or adults involved in the activities). Moreover, the evaluation matrices were inspired from the range of domains of active learning that UNAWE covers, differentiating between children and teachers. The domains of active learning (DAL) for children lies mainly in the motivational sphere and they are: scientific skills, knowledge and inter-cultural attitudes (Figure 5.3). We can see in Figure 5.4 the evaluation matrix for children.

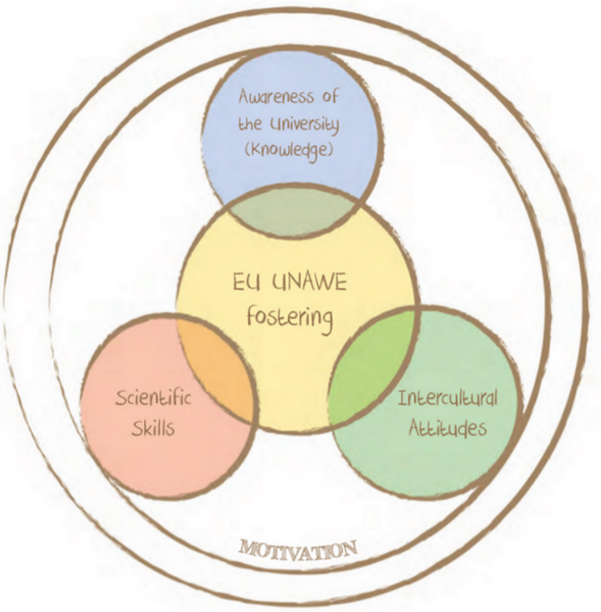


Figura 5.3: The domains of active learning for children.

	Objectives	Evidence
Motivation	Enjoyment, Inspiration Curiosity Tenacity	• Children are doing the tasks with pleasure • Children seem enchanted • Children react with diligence in front of the proposed activities • Children demonstrate attention • Children apply perseverance / tenacity • Children manifest inquisitiveness • Children introduce some complex questions
Scientific Skills	Develop Scientific Thinking & Problem Solving Techniques; Planning & Conducting Investigations Observation, Identification, Classification, Making interconnections, Changing Perspective & Communication From curriculum: example of school wording of this section Discussing and Questioning Ask questions which can be answered through an investigation Use scientific language regularly in discussions Planning Plan and carry out a test to collect evidence Select information from a range of resources Observing Decide what observations need to be made Select appropriate equipment for observation or measuring results Interpreting Draw conclusions linked to scientific knowledge and understanding. Recognise patterns and trends based on the observation or investigation Ideas and Evidence Recognise that scientific ideas are based on evidence which can be verified by observations Use the imagination together with scientific knowledge to understand and think about why something happen Recording Decide on an appropriate method of recording Present results using tables, graphs, pictures Evaluation Review the work and reflect on the results	• Correct use of vocabulary or gesture to name objects and phenomena observed in sky • Grouping objects/ phenomena to indicate developing understanding of astronomy concepts • Making conjectures available to be contrasted • Developing some experiences related to the hypothesis • Linking new information with existing conceptions of the same or different areas • Removing previous points of view according to new inputs • Sharing with others their new knowledge

	Objectives	*Evidence*
Universe Knowledge	*Knowledge & Understanding* *Observing, exploring and discovering:* *1. The Sun, Sun relative position, Sun light (shadows), Day/night cycle, time zones, the seasons, the Moon, the Earth as a planet, awareness of the existence of water and of the Earth atmosphere and Sun light for the development of life on Earth, Solar and Moon eclipses,...* *2. The Solar system: planets characteristics and movements, wharf planets, asteroids, comets,...* *3. The Stars in the night sky, the constellations, orientation, the Life-cycle of stars, the formation of stars and planets,...* *4. Our place in the Milky Way, Family of galaxies,...* *5. Current developments in astronomy* *6. Magnetic fields (compass, northern lights,...)* *7. Several complementary questions*	*Direct observation and/or recording of naming, first explanations, discussing, drawing, construction, creative responses, movements and dances, etc. to demonstrate knowledge of one of the features listed. left*
Intercultural Attitudes	*Valuing different cultural perspective. Recognising different physical perspectives. Positive attitude towards astronomy. Valuing inclusive education* *Working Individually & in Teams*	• *Demonstrating awareness of different cultures* • *Ability to observe and explain differences in phenomena in different countries* • *Statements of future activity with regards to astronomy* • *Act on an appropriate way in a frame of diversity*

Figura 5.4: UNAWE evaluation matrix for children.

On the other side, the evaluation matrix for teachers is basically the same but with an additional area of impact: legacy (Figure 5.5). This means that

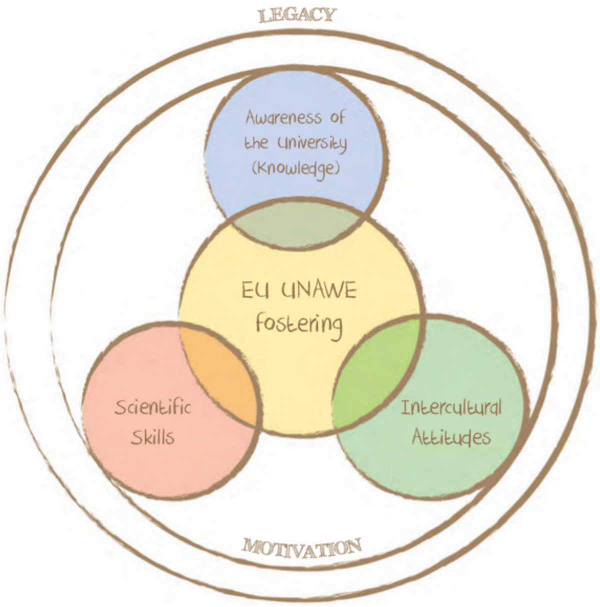


Figura 5.5: The domains of active learning for teachers.

teachers gain subject knowledge for teaching their pupils in the domains previously explained. In addition there is potential for the impact of the project to be multiplied through:

- Teachers disseminating knowledge
- Teachers critically appraising resources and activities, in order to make recommendations for future projects
- Embedding astronomy activities into curriculum.

We can see the matrix evaluation for teachers, which in this case becomes an Astronomy Awareness Framework, in Figure 5.6.

	Definition
Motivation	1. Enjoyment 2. Inspiration 3. Creativity 4. Persistence
Scientific Skills	1. Curiosity 2. Observation 3. Identification 4. Classification 5. Making interconnections 6. Changing perspective 7. Communication
Knowledge	Observing, exploring and discovering: 1. The Sun, Sun light (shadows), Day/night cycle, the seasons, the Moon, the Earth as a planet, awareness of the existence of water and of the Earth atmosphere and Sun light for the development of life on Earth, Solar and Moon eclipses. 2. The Solar system: planets characteristics and movements, wharf planets, asteroids, comets. 3. The Stars in the night sky, the constellations, the life-cycle of stars, the formation of stars and planets 4. Our place in the Milky Way, Family of galaxies 5. Current developments in astronomy
Intercultural Attitudes	1. Valuing different cultural perspectives 2. Positive attitudes towards astronomy
Legacy	1. Disseminating knowledge to other teachers 2. Recommendations for improvements 3. Embedding new materials in curriculum

Figura 5.6: UNAWE evaluation matrix for teachers.

At this point it is possible to explore the evaluation process step-by-step. We can divide it into three stages:

- Planning;
- Data Collection;
- Data Analysis and reporting.

5.3.1 The Step-by-Step Evaluation Process

Every stage of evaluation process is divided into several steps. It is proper we examine the steps in detail and, although it is still work in progress, see how UNAWE copes with the different stages.

Stage I: Planning

- **Step 1. Re-examine the issue, audience and project objectives**
  Before a project evaluation can be designed, it is essential to understand fully the project – its components, the relationships among the components, the audience(s), and the intended outcomes. The project goals and logic model should be examined and used as a roadmap for planning the evaluation. With the logic model and the associated performance objectives in hand, evaluation planners will be able to articulate how the project is supposed to work.

  We have already seen that UNAWE has accomplished the logic model and created the evaluation matrices. Regarding the specific performance objectives, an evaluation concept of UNAWE programme must be strongly linked to its general and specific goals we have seen in the previous chapters.

- **Step 2. Establish the planning team (including stakeholders, audience and evaluators)**
  The project, in all likelihood, involves a variety of players. Each plays a different role and sees the project through a different lens. These perspectives should be tapped when planning an evaluation. The exact expectations of planning team members need to be decided and articulated early on in the process.

  UNAWE evaluation team is composed by three people:

  - Dr. P. Russo: UNAWE International Project Manager.
  - Dr. C. Scorza: staff member of Haus der Astronomie (Centre for Astronomy Education and Outreach in Heidelberg- Germany - and UNAWE partner) and member of the IAU' s Office of Astronomy for Development.
  - Dr. G. Kimble: external Education/Evaluation Consultant.

Furthermore, the evaluation team uses the help of UNAWE' s collaborators and volunteers to gather data.

- **Step 3. Identify a purpose for the evaluation**
  The evaluation team will need to determine the scope of the evaluation – that is, define the purpose of the evaluation, what is going to be evaluated and who will use the evaluation. If the purpose is to assess the extent to which a program is operating as planned or to collect evidence of progress, then a process or implementation evaluation is called for. Instead, if the purpose of the evaluation is to judge whether the goals of the project have been reached then an outcomes evaluation is warranted.

  At the moment UNAWE' s purpose is to evaluate the quality and feasibility of the resources, as well as the achievement of educational and pedagogical goals. To do so, the short-term outcomes in the cognitive and affective domains will soon be evaluated, thus it will be performed a formative evaluation. In addition, UNAWE plans to implement a summative evaluation for the medium-term outcomes, in both the affective and cognitive domains. Although UNAWE recognises that long term impact is a question frequently asked in evaluation. However, until now, the demonstration of long term impact is not stated as an evaluation outcome for the UNAWE evaluation programme yet.

- **Step 4. Focus on project improvement**
  The purpose of implementation evaluation is generally for project improvement. This type of evaluation focuses on what services are provided and to whom and how. The intent is to strengthen the programme by providing feedback on its implementation, progress and success based on short-term outcomes. If we consider the process evaluation as a staircase (Figure 5.7), the project improvement generally occurs at the lower four levels of the project evaluation staircase: resources, activities, participation and reactions. UNAWE has already done this kind of implementation during its first years, when the UNAWE team tested the feasibility of the project. Moreover, UNAWE even now continues to consider these aspects when its activities are carried out.

- **Step 5. Assess project outcomes and impacts**
  The project's objectives are set at all levels of the programming staircase based on need or opportunity assessment. Outcome evaluation assesses the extent to which those project targets are reached. In addition, the outcome evaluation generally occurs at the upper three levels of the programming staircase (Figure 5.7) (knowledge, attitudes, skills and aspirations (KASA), practices and social, economic and environmental (SEE) conditions). Results of an outcome evaluation provide the information necessary to make decisions about the continuation, revision or expansion of the project.

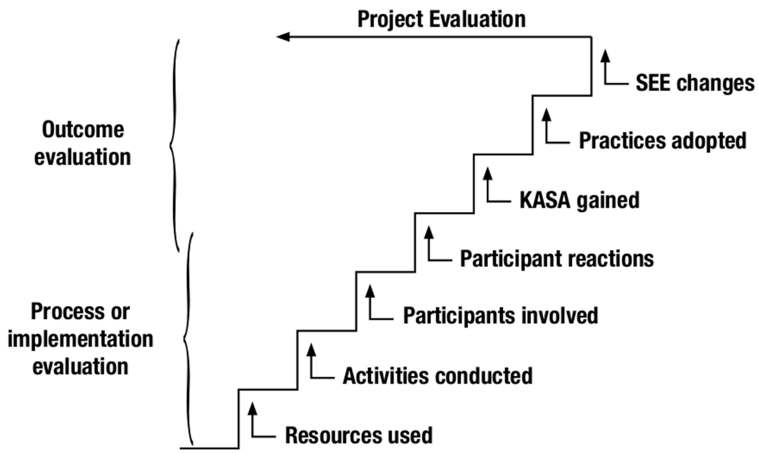


Figura 5.7: Ascending TOP' s Project Performance Staircase.

UNAWE has already in part passed this step (above all with the pre-existing resources) and the reply to this assessment lies in the development of the structure model to follow to develop the activities, their transformation into OERs and the idea of the Peer-Review Platform. All subjects that we have seen in chapter 3 and 4.

- **Step 6. Clarify the time frame in which the activities and impacts (outcomes) are expected to occur**
  The relationships between overall project design and implementation and project evaluation design and implementation cannot be over-estimated. Project evaluation is integral to project design. Sufficient care must be given to the development of the evaluation time line to ensure effectiveness.

  For the UNAWE existing OERs, the actual evaluation development, from the collaborative agreement of objectives to the final research publication [2], will take in total a couple of years. UNAWE is now just in the middle of this process. Even the Peer-Review Platform is in the testing phase, as regards both graphics and styles, contents and soon the resources after the meticulous revision process that we have seen in section 4.3. Moreover, maybe in the future, UNAWE will use additional methods of data gathering and evaluation, which will facilitate future assessments. As instance the wiki model we have introduced at the end of the previous chapter.

- **Step 7. Perform a literature search (to establish benchmarks or standards; if appropriate)**

[2] The entire evaluation development involves: collaborative agreement of objectives, objectives developed into framework, framework collaboratively modified, existing data submitted, data collection, interim data summary, highlight priorities for data collection, analyse data, finalise evaluation report, disseminate evaluation findings and finally research publication.

Evaluation, like the overall project planning and the project itself, always is developed based on explicit or implicit theories. In designing an evaluation it is helpful to consider the related literature and use this literature as a touchstone. Indeed, UNAWE has taken care to design a research methodology that acknowledges the strengths in a multi-national project and also allows for data from different locations and activities to be combined. This has led to the development of the UNAWE programme evaluation guide [3] that supports to gather evidence with the aim of demonstrating a full range of impacts for teachers and pupils. Moreover, this thesis includes an example of literature search performed to sustain the points of view of UNAWE project.

Stage II: Data Collection

- **Step 8. Determine the audience sample**
  Evaluations will be limited to a subset of the total anticipated audience. The preferred method for selecting the subset is random sampling – using procedures that will reduce sample bias and response bias by selecting a sample that accurately reflects the population. The larger the sample, the more generalisable to the population – that is, it more accurately reflects what would be obtained by evaluating everyone in the population. This is exactly the UNAWE strategy in this case.

- **Step 9. Design and pilot data collection instrument**
  Just as the initial design of the project required careful design and pilot testing of instructional materials to see how they worked, the data collection methods or tools (e.g., interview, focus group, survey, observation) need to be crafted and tested. The evaluator will need to establish the nature of the data collection instrument(s).

- **Step 10. Gather and record data**
  Again, just as the design of a project requires the consideration of various logistics, the data collection process must be thoroughly scoped. The evaluation team will need to determine how data will be collected. A system of coding and recording the data must be developed to ensure easy and accurate data analysis. An example of data collection methods targeted for different types of audience and for different activities/projects is in appendix E.

  UNAWE decided to gather evidence about children's learning from children themselves, from National Managers and from teachers. In order that the data collection is realistic, a number of qualitative evidence collection routes are used to gather the necessary data. We can see the process diagram of evidence gathering in Figure 5.8

[3] http://www.unawe.org/resources/guides/EU_UNAWE_evaluation/

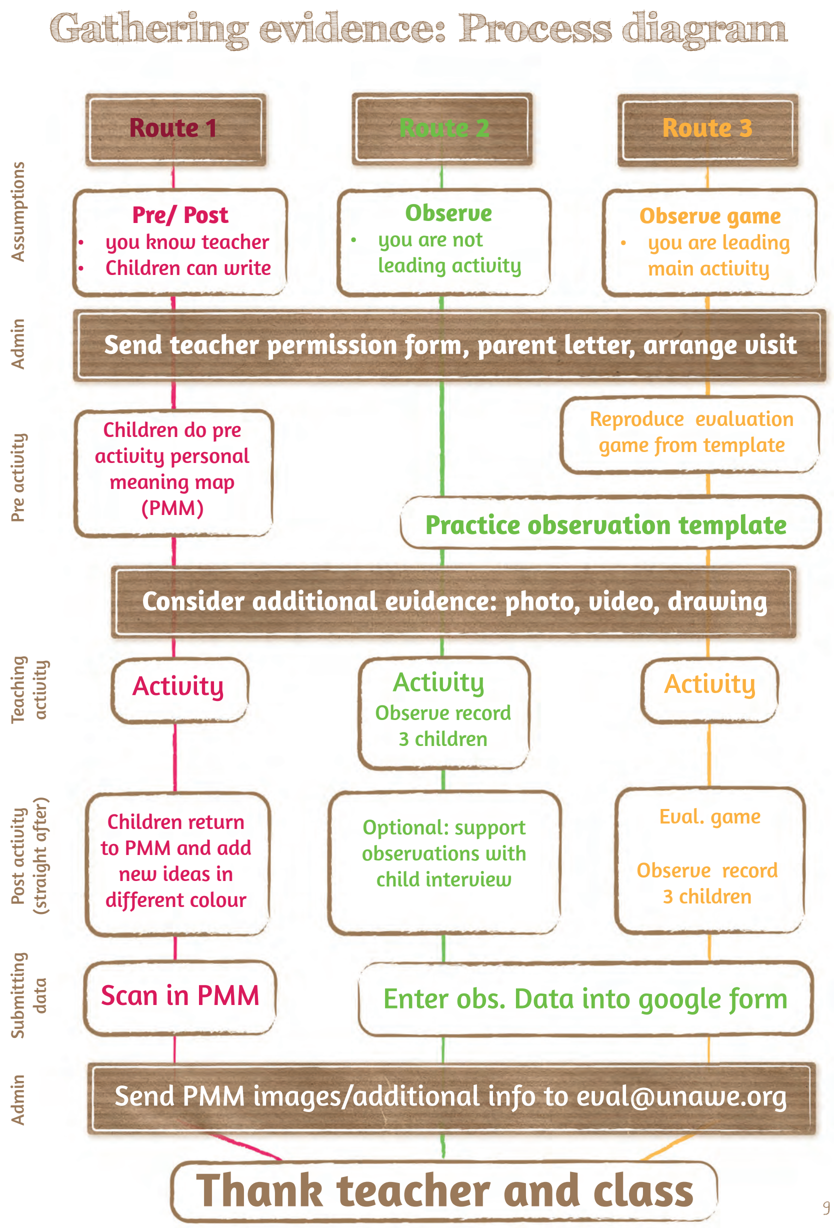


Figura 5.8: UNAWE Process Diagram of Gathering Evidence.

Indeed, who is gathering the data, uses pre/post activity mind maps/drawings and observation template (for children who are too young to write). In addition, quick evaluation with astro-posters, astro-card games, photos and videos are all admissible as evidence. Excellent practice is already taking place around teacher evaluation using quantitative and qualitative questions on survey forms. Based on good examples supplied by National Managers, questions have been developed in order that data can be collated and logically correlated with the Astronomy Awareness framework for children's learning. In addition to all this, surveys (with e-form) are supplied for gathering evidence from teachers and pupils (8-10 year olds) who are old enough to write [4]. For examples of UNAWE data gathering tools see appendix F.

In this moment the UNAWE evaluation process lies at data collecting and this part of the process will take efforts for a little while yet. Afterwards, UNAWE will deal with the third stage of the evaluation process: Data Analysis and Reporting.

Stage III: Data Analysis and Reporting

- **Step 11. Perform data analysis**
  Analysing quantitative and qualitative data is often the topic of advanced research and evaluation. There are a few basics that can help in making sense of the data:
  - Have a plan in place for how to analyse, synthesise, store and manage data before starting the data collection.
  - Develop a plan to guarantee an unbiased analysis and reporting of the data. Always start analysing the collected data with a review of the evaluation goals and objectives.
- **Step 12. Manage data**
  After the data are collected and even after the data have been analysed, a plan must be put in place to continue the effective management of the data. Indeed, after reading the evaluation report, decision-makers, other stakeholders and other evaluators may generate questions that can be answered by revisiting the data. Consequently, it is important to develop a plan for continued access to data.
- **Step 13. Synthesise information and create report**
  After the data have been collected and analysed, an evaluation report must be written. There are standard components to any evaluation report. For example, the report must include a description of the evaluation methods used and any errors.

[4] The addresses of the online surveys are http://goo.gl/XejyP and http://goo.gl/yJQY5

Even if the data collected so far are incomplete the results of this preliminary assessment are good and encouraging.

5.4 First Evaluation Results and Advices for the Future

UNAWE has started to collect data during and after the performance of activities since the end of 2011, calling for both children and teachers to express their opinions and/or verifying the acquired knowledge and skills. We are talking about the cognitive and affective domain, but for short-term outcomes. Moreover, for some groups that have carried out the UNAWE activities following a larger programme, which covers more years, the medium-term outcomes in the cognitive domain have been assessed. While in the affective domain, UNAWE tries to figure out which are the most popular activities and why. So, as we have seen in the previous section, the performed evaluation will be formative and summative, but reaching at the maximum the medium-term outcomes.

The gathering of data occurs equally in every country (Figure 5.9) in which UNAWE is active and the feedbacks received, although not yet representative to judge the project UNAWE, have been extremely positive. Obviously with little

Figura 5.9: Examples of activities performed in different country.

nuances from country to country, nuances also linked to the met socio-cultural environments. For example there are activities as Spicy Solar System or Scale and Distance Worksheet in which children can create a model of our Solar System. This model aims to represent the Solar System to scale (sizes and/or distances of the objects) and to make learn the relative sizes of the different types of planet in our Solar System and the huge distances that separate them. In addition, children can play several games with these activities, for instance ordering the planets according to their distance from the sun (Figure 5.10). To perform these

Figura 5.10: Students try to perform a model of the Solar System.

activities teachers can buy models (Figures 5.11) of the planets to scale (as usually happens in privileged environments), children can build or draw them (Figures 5.12). They can also use edible ingredients or everyday objects (Figures 5.13) that can easily be found in many environments, as fruits, seeds, spices and balls (as usually happens in underprivileged environments). The nuances lie in the fact

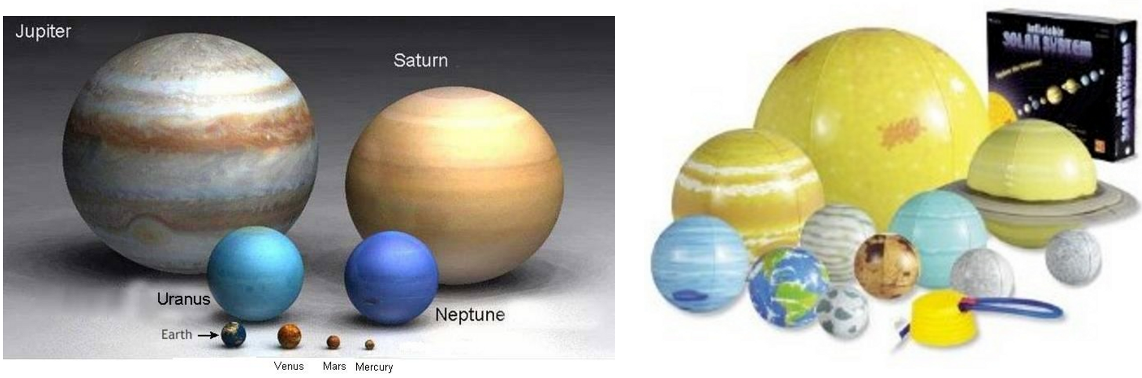


Figura 5.11: Examples of Solar System models to buy. Credits: http://daddytypes.com/2009/10/08/inflatable_solar_system_just_like_the_white_house.php and http://www.essex1.com/people/speer/model.html

that children from privileged environments are happy to perform the model with

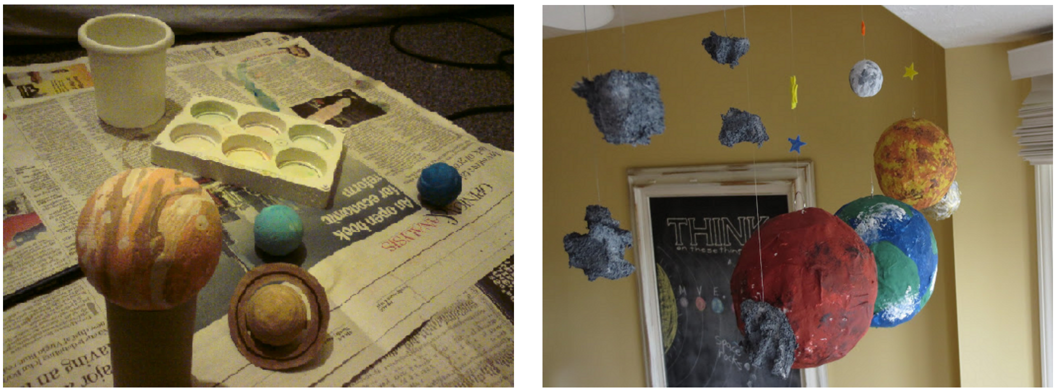


Figura 5.12: Examples of Solar System models built by students. Credits: model2 e 3 e painting: http://craftyhomeschoolmama.blogspot.nl/2013/01/the-ultimate-paper-mache-solar-system.html

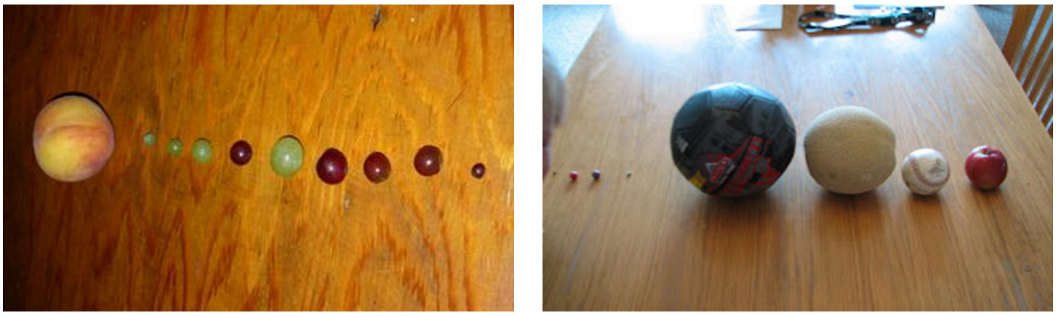


Figura 5.13: Examples of Solar System models created by students with edible ingredients or everyday objects. Credits: http://science-mattersblog.blogspot.nl/2010_12_01_archive.html

every kind of Solar System but they are easily bored and prefer to build their own Solar System. On the other side, children from underprivileged environments are always super enthusiastic to perform the Solar System model even with seeds or spices. These different approaches to the activities must make think about and they must be considered by those who develops the activities or adapts them to different environments.

We report some case studies to give a few practical examples of how children and teachers, reached and treated by UNAWE, have responded to activities or workshops.

- In a case study in Spain, carried out in different places in the first six months of 2012, UNAWE has tested the learning of new astronomy contents and their improvement over time (Figure 5.14). As we can see there was an incredible improvement.

- In this case study in South Africa, carried out in July-August 2012, UN-

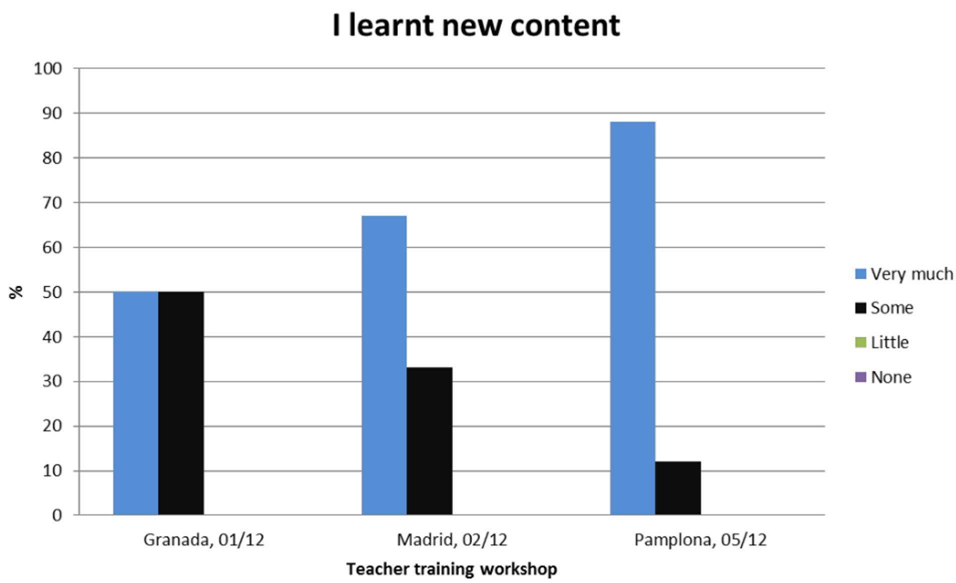


Figura 5.14: Histogram that represents learning of new astronomy contents and their improvement over time.

AWE has tested the astronomy learning outcome (knowledge and skills). The learners didn't have any (or very few) previous knowledge about the arguments. As we can see in Figure 5.15 there was a good percentage of learning.

- In another case study in The Netherlands, carried out in March 2013, the teachers replied in a positive way to the question: Did you develop any new skills or practice existing skills? For example teachers stated (many focused on pedagogical approach as a skill they had acquired): New skills! Enquiry learning and how I can use it in my classroom. How to explain clearly to children using visuals. The usefulness of discovery learning.

- In one of the most recent case study (April-June 2013), carried out in Sao Paulo, Brazil, the teachers said that the activities held were all suitable for the age range in attendance and each of the learning goals were successfully achieved. They also highlighted some met challenges:
  - Discovering how long to spend on the presentation section of the activity, due to the range of different age groups (between 6 and 8 years).
  - The oldest children were harder to engage and seemed happier and more attentive when a shorter, condensed version of the presentation was given.

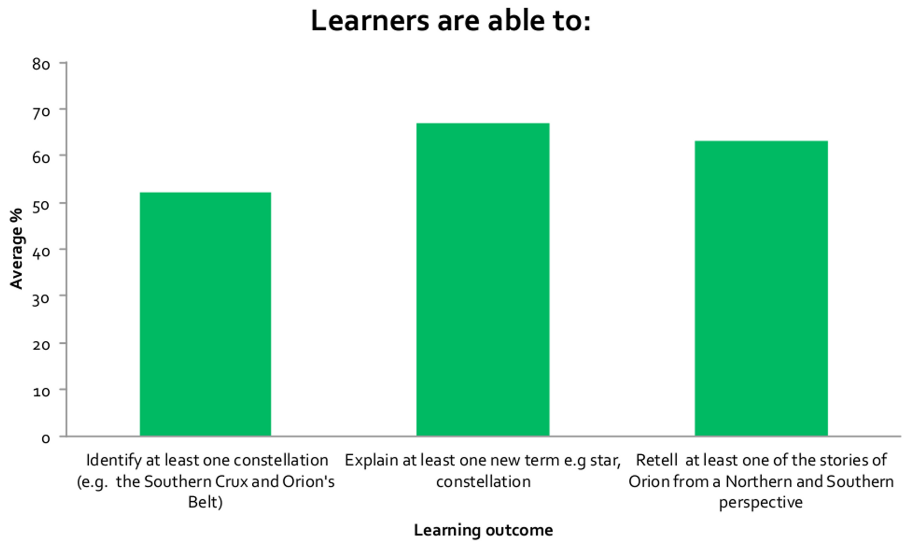


Figura 5.15: Histogram that represents the percentage of astronomy learning.

  – Even when working with the same children twice, their attention span can vary from day to day.

- We can name another few: for example in South Wales the teacher said: The event was the first time that the children of the school had had chance to look through a telescope. The vast majority of pupils had never seen the Moon through a telescope and were visibly impressed by the details visible.
- Another instance in North Carolina, United States, where the teacher said: It was a very successful activity. We received good feedback from the audience during the activity and afterwards. They were engaged during the interactive parts.

As we can see from these examples, the results obtained so far do hope for the best. Moreover, they show us that the way taken by UNAWE seems to be the right one. Now we just have to wait until this phase is completed and the data properly analysed to get the final verdict ant to better understand the real value of UNAWE project.

As with all assessments of major international projects as UNAWE, it will take time to get the final results and even then the evaluation will not be totally completed because surely new challenges will arise. But at least we will have a clear idea of the value of the programme UNAWE and objectives that have been fulfilled and those which will have to meet in the future.

Unfortunately, the evaluation process is not simple. First of all it is necessary an international cooperation among the various national manager and the evaluation team to improve the evaluation process and make it suitable for different environments. Therefore, this phase requires time. Secondly, there is a reluctance to fill the forms necessary for the assessment by teachers, volunteers and people involved in the project. This is probably because filling out forms or carrying out the required examinations in the classroom with students takes time and efforts. The people involved are not always prepared for this.

A possible solution to this problem would be to create shorter forms, where the answers are a maximum of two sentences or even better at multiple response. This could be useful to reduce the compilation time and not discourage those who have to fill the forms out. A further stimulus may be giving (a sort of prize) to those who fill the forms, on the designated time after completing the activities, useful gadgets and materials for teaching science education. With regard to assessing the achievement of the objectives on the students, it would be helpful to prepare verification methods (or adjust existing ones), to be incorporated in the methods that teachers use to verify the achievement of the objectives of the national curriculum. So that they don't require additional time.

Another important point on which we want to draw attention is the evaluation of the long-term results. That is, the impact that the UNAWE project will have in the future on children achieved from its activities. In the final part of UNAWE programme evaluation guide, although not included in the guide, there are some suggestions to gather supporting information for a possible evaluation of this type. UNAWE evaluation team says that interviews to assess long-term impact require:

- Search records for a class that you can still contact, who have taken or will take part in UNAWE activities.
- Contact a teacher at the school and request an interview with him/her and a group of pupils.
- Record age, date, name, school and year of UNAWE participation of everyone.
- Use questions for an interview and, when possible, encourage conversation around the key questions and discuss responses with the group.
- In addition, it is then necessary to find a control group of pupils the same age, who have not taken part in UNAWE activities.
- Repeat the entire process at predetermined time intervals with the same groups (treated and control group (s)) to see their evolution over time.

We would like to suggest a programme to follow in the future, to put into practice this important type of evaluation. It would be interesting to follow the two groups over a vast period, as researchers did, for example, with the HSPP [5] we have seen in section 2.2. This would certainly help to have an impact assessment on a large scale. Furthermore, it would also be interesting to differentiate the assessment for developed and developing countries. So it can be possible to observe the different evolutions in the two environments.

Basically, our idea for a long-term evaluation is structured as follows. The UNAWE team could start by evaluating the satisfaction and the acquired knowledge and skills at the time of conducting the activities (even if it is a training programme that lasts several years). Then repeat the interviews a year later and the third and fifth year after treatment. Thus concluding the first cycle of interviews covering outcomes in the short and medium term. UNAWE evaluation team is actually already performing these types of evaluation, as we have seen in this chapter. From now on, it begins the second phase of interviews to perform every 5 years until the fifteenth year after the participants were treated the first time. Moreover, in this second phase, the assessment of how the knowledge and skills acquired are applied in various fields and not just in the school must also be included. Adding also how applying the acquired skills can affect the life choices of the participants, such as the type of study and job. At this point it begins the third and final cycle of interviews that UNAWE could develop into two sessions: one the twenty-fifth year following the treatment and one of the thirty-fifth, that is, when participants will have respectively about thirty and forty years. Here UNAWE will see the true long-term results of treatment. They will be reflected not only in knowledge and skills but also in jobs held by the participants (perhaps in the scientific field), in their style and their choices of life and in their reached degree of well-being.

Particular attention must be given to the content of the interviews and the issues to be considered. It would be useful to develop relatively fast interviews, using, where possible, scales of satisfaction (for example from 1 to 10 with 1 = dislike and 10 = like very much) and short questions, but designed to meet all the necessary arguments. In this case, the ideal thing is that these questions are developed in collaboration by experts in various fields (science, education, pedagogy, psychology, social sciences). Surely fixed questions, to repeat in each cycle of interviews, will serve. For example: Do you ever observe the night sky? How do you feel about astronomy or science? What have you learned from the treatment? Do you think you have used or will use what you learned in astronomy? And then specific questions, to attach to the fixed ones, must be developed. Specific questions for each cycle and for the goals that UNAWE wants to evaluate.

An evaluation project of this kind takes for granted the survival of the project UNAWE, which unfortunately cannot be taken for certain. But UNAWE can always develop the series of interviews one at a time, as if they are three different projects and perform them when the right time comes. Prerequisite, however,

[5] High Scope Perry Preschool Programme

take care to maintain contact with the treated and control groups. Surely, an ambitious assessment of the impact of this kind would provide a more than valid proof of the value of the project UNAWE, a value that is already clear in the minds of those who conceived the project and who is carrying out with such care and dedication.

Conclusions

For an educational project, it is important that an evaluation is built into the plans from the start. A well-crafted project evaluation helps decision-makers make their decisions by determining if the project works and whether or not it is worth the investment of time and resources. Equally important, the data from a well-conducted evaluation can also help to improve the project and to shape future efforts so as to provide more effective, better targeted and more widely used programmes to the public. Furthermore, a good evaluation to be complete should include different types of evaluation: formative and summative. It should therefore cover both cognitive and affective domains and should include outcomes in the short, medium and long term by using mix of data collection methods from observations to interviews and surveys.

Following many guidelines extracted from the literature, UNAWE has developed an accurate programme of evaluation that involve all these mentioned aspects, even if the programmed evaluation is targeted to medium-term outcomes. This evaluation process is still in progress so there are not yet enough data to make a detailed analysis (this will be the next step for UNAWE team), but the results collected so far are very good. This gives hope for positive final judgments of the UNAWE programme.

Despite the fact that unfortunately at the moment UNAWE doesn't include an assessment of long-term impact in its programme, we consider that will be very important to develop this long-term evaluation. This means planning an evaluation that arrives to interview the participants when they are adults, up to 35 years after having been achieved by the UNAWE's activities. For UNAWE there is the possibility of developing this evaluation in the future and we definitely hope that it will be performed.

Ultimately, it will take many years before the long-term specific impact of UNAWE can be formally evaluated, but considering the bases from which UNAWE was created and the attention UNAWE pays to the quality and development of its projects and materials, not to mention the fact that UNAWE always considers the needs of his audience, then we already know the value of the UNAWE project. In conclusion, UNAWE is an extremely valuable astronomy educational project and the evaluation's results will only serve to prove this to everyone.

Capitolo 6

Conclusions

We retrace the key points which were presented and discussed in this composition. To begin, we can argue that the meaning of the science education's concept and its evolution, over the past one hundred and twenty years, have been crucial to define the general context in which we have developed the central theme of the thesis. Indeed, science education has evolved from the simple transfer of knowledge, held exclusively by formal education, to the current single body composed of knowledge, process and way of thinking. Moreover, this single body is acquired through all types of education: formal, non-formal and informal.
Nowadays, it has become important to consider these three types of learning as inter-penetrating and complementary. For this purpose, and to achieve the maximum effect on students, teaching methods must adapt to this conceptual change and take advantage of all learning types. In addition, it is considered important to intervene in pre-university learning with well structured science education, not only to train future scientists, but also future citizens. They will in fact be able to build a better future through applying, to all aspects of life, the knowledge, skills and the particular way of thinking taught by science education.

In this context, we observe that astronomy is perfectly suited to this role, and also to achieve the goals of science education. This is because astronomy is especially equipped for enquiry-based learning, is highly interdisciplinary, and it is one of the oldest and most fascinating subjects – all things which make the study of science more attractive and exciting. But above all, with its discoveries, the mysteries still unsolved and the wonderful images of our universe, astronomy fascinates and inspires everyone, from children to adults of any country and walks of life. Indeed, worldwide many educational and outreach programmes use astronomy as a basis for their work in consequence of its multiple nature.

Among all, we have specifically seen Universe Awareness - UNAWE - a project with which I have worked for six months in order to write this thesis. As we know, UNAWE was founded in 2005 in the Netherlands, at the University of Leiden, thanks to the idea of the astronomer Professor G. Miley. Today UNAWE has

more than 50 member countries worldwide and a global network of more than 800 astronomers, educators and teachers. Furthermore, UNAWE can also boast the support and backing of the International Astronomical Union - IAU.
Since its inception, UNAWE has decided to focus its efforts on a target audience composed of children aged 4 to 10, giving particular attention to those from disadvantaged backgrounds. Its goal is to inspire the future generation of scientists and engineers and above all to encourage children to become curious, tolerant and internationally oriented adults. A secondary objective involves encouraging them develop skills such as logical reasoning, problem solving and creativity, which are important to improve and maintain the society and the economy. In addition, several studies in psychology, education and science support the choice of the UNAWE's particular audience.

This research shows that, in spite of what was thought up to 10 years ago, young children's learning mechanisms are not illogical and irrational. On the contrary, even if children are not consciously aware of this, they are actually very close to the way the scientists learn and think. In addition, the structure of the brain at that age is particularly susceptible to the environment in which it grows. Therefore, children will reap great benefits if properly stimulated and guided in developing their innate abilities. Basically, the research claims that young age is a good time to get in touch with science for the first time. All of this lays the foundation for the future of these children and will stimulate skills, motivation and learning later in life. It is also shown that the benefits are greater on children from disadvantaged communities because this type of intervention gives them the opportunity to have a more equal start in life and greater success as adults. Moreover, let's not forget the economic side: in fact, there is ample evidence that the earlier the action is taken in the science education of children, the less expensive it is and the greater the involved benefits are.
Therefore, considering all these aspects, for an astronomy educational programme such as UNAWE, the best strategy to help improve performance, have more equality, and reduce socio-economic disparities over time, is to invest in young children, especially in disadvantaged ones.

To achieve these goals UNAWE engages in many activities and projects. It is involved in ambitious international projects such as the IAU Strategic Plan 2010-2020, Astronomy for Developing World which aims to help achieve the Millennium Development Goals with the purpose of reducing inequalities, poverty and stimulating education for all. In addition, in the various countries where UNAWE is active, it deals with public outreach, teacher training, development of educational materials and creation of an international network to share ideas, knowledge, materials and resources.

A this point, we have focused on the development and improvement of astronomy educational materials, because it is an activity that I have personally dealt with. Indeed, UNAWE pays particular attention to the development of high quality educational activities. For this purpose and to ensure the quality from a

scientific and pedagogical point of view, the team decided to design a structural model and to give precise guidelines to be followed for the creation of resources. In addition, they decided to also use a process involving peer-review of the content. Care and commitment are put into every aspect of a resource: from the choice of goals and content, which hands-on activities are to be included, how to write the text and the most appropriate language, all the way to how to perform the activity to children. Of course, the fact that the audience is composed of young children and that the activities are mostly used by teachers and educators of these children exerts the most influence. Therefore, all aspects have to be adapted to their particular needs. From this comes the choice to share and distribute resources as Open Educational Resources (OERs) through the UNAWE website. The UNAWE team, driven by a vision of knowledge as a public good, has wanted to make the material free and accessible to all for all types of educational purposes.
This choice, however, raises a number of challenges. In fact, in recent years the OERs have become a real movement and the increase of open resources on the web has made the research of efficient astronomical educational resources a difficult task. Furthermore, it is especially difficult to understand which resources are of a high quality and are actually up-to-date.

UNAWE's reply to this problem lies in the design of the new and unprecedented Peer-Review Platform accredited by the IAU, through which high quality educational material for young children and their teachers is made available. This material also enjoys a high visibility on the web, thanks to Search Engine Optimization methods. Moreover, to ensure the set quality standards, inspired by the methods used in scientific research, UNAWE has developed a meticulous process of astronomer-educator double peer-review for every existing and future resource. In the process, an editing of the resources carried out by an editorial board is also involved. Finally, everything is overseen by a curator who will decide which resources meet the required quality levels and will therefore be published in the platform. The framework to be met is basically that of the 5 Rs, i.e., reuse, revise, remix, redistribute and review the resources. The UNAWE platform will be the first in the world to satisfy all the 5 levels.
Another interesting aspect of the platform is that anyone can submit their activity for review by UNAWE. If this activity makes it through the whole process and it is inserted in the repository, it will then be published and disseminated in different formats, to fill the various needs of the public. In addition, the successful activities will be translated into all the languages of the partner countries, with care taken to accurately treat the linguistics and inserting cues from the respective cultures, which is important because language and culture cannot be separated.

As a result of contributing to the development and improvement of UNAWE astronomy educational material and supporting the creation of the new platform, we came up with the idea to suggest an implementation of the project. This idea is inspired by the famous wiki the free encyclopedia Wikipedia website that allows its users to add, edit or delete content: one day UNAWE could make the platform a wiki. Thus it will be possible to ensure that the material is constantly updated and of high quality, thanks to the direct intervention of the user community.

For completeness, it becomes necessary to discuss the assessment of the actual quality and feasibility of the UNAWE resources and project. First of all, a good evaluation should include the cognitive and affective aspects, use a variety of data collection methods and consider all types of outcomes (short, medium and long term). This is helpful to evaluate every aspect of the impact of an educational project of this magnitude and to enable the necessary improvements and adjustments. Indeed, UNAWE has designed and is putting into practice an accurate evaluation programme. At this time UNAWE is in the data collection phase, so it isn't possible to make the final assessment of the value of the project yet, which will require more time. However, the first obtained data shows the achievement of goals in the short and medium term, an excellent response from the audience, and that the project is of good quality.

In addition, we have identified a deficiency in the evaluation programme: the fact that there isn't a long-term assessment, which is important to determine the project's impact on teaching and learning and to ensure that all the goals are achieved. So we have made a proposal on how to implement and add this type of evaluation, something which is, in our opinion, very important. A proposal that, if implemented in its entirety, will assess the achievement of the objectives on children treated by UNAWE when they will reach the age of approximately forty.

In conclusion, this work reflects the great importance that the UNAWE astronomy education project has, not only in the popularisation of astronomy, which forms the basis of the project, but also in the use of astronomy as a means to achieve higher goals, which are certainly important for the future of the society. Surely, it's not easy to keep such a large project alive. Moreover, in difficult times such as the present, it definitely it gets overshadowed by many other projects. Indeed, it's common to wonder why we use resources, energy and funds in an endeavour to introduce children to astronomy, when instead we have to worry about guaranteeing them the basic necessities which they need to live – essential things which should be provided in the short term. Nevertheless, it would make sense consider the enormous benefits which, as we have seen, result from the development of these projects. These benefits improve the quality of life in the long term, reach many aspects of the lives of individuals and are accordingly reflected in society. In addition, bearing in mind that we can have all of this, if designed and prepared with care, for a small fraction of the total national expenditure, then maybe every country in the world would have its own UNAWE or similar project. Probably, we would also care more about the teaching of science education. In fact, it is clear that science education is important, but it is also important to learn to execute it in the best way possible, even knowing that it is a path with many challenges and difficulties. Obviously, this does not solve the problems permanently, but can be a substantial aid in solving them. There is indeed evidence that an increase in the consideration and care of science education has resulted in many countries having a greater well-being, economic stability and an increase of development.

Personally, knowing the importance of science education and the role of astronomy within it, the discovery of its benefits and properties at such deep levels was a lesson that, among others, I have learned. I also had the opportunity to teach and especially to learn from people with different experiences and knowledge. It was exciting and fascinating to find together new and innovative ways to divulge astronomy and fascinate children. In the end I can say I have gained much from this experience; indeed I believe that it has allowed me to grow not only as a person but also as an educator and astronomy promoter.

Appendice A

Forms of Learning

The three forms of learning officially defined by the Organisation for Economic Co-operation and Development (OECD) in 2007 [146]: formal, non formal and informal.
Formal learning
This type of learning is intentional, organised and structured. Formal learning opportunities are usually arranged by institutions. These include credit courses and programmes through community colleges and universities. Generally, there are learning objectives and expected outcomes. Often this type of learning is guided by a curriculum or other type of formal programme.
Non-formal learning
This type of learning may or may not be intentional or arranged by an institution, but is usually organised in some way, even if it is loosely organised. There are no formal credits granted in non-formal learning situations.
Informal learning
This type of learning is never organised. Rather than being guided by a rigid curriculum, it is often thought of as experiential learning. Critics of this type of learning argue that from the learner's viewpoint, this type of learning lacks intention and objectives. Of the three types of learning, it may be the most spontaneous.

Adapted from Organisation for Economic Co-operation and Development (OECD) [146].

Appendice B

Educational Material

TOPIC	ACTIVITY NAME	TOPIC	ACTIVITY NAME
Models and Instruments	Periscope	**News and Stories**	Space Scoop Storytelling
	Magic Levitation		The Sun and the Moon
	As the World Turns		The Legend of Yacana
	Scale and Distance Worksheet: Relative Sizes in the Solar System		Dream of the Gods
	Scale and Distance Worksheet: Distances in the Solar System		A Rabbit in a Pot
	Lunar Phase Viewer		Algol, the Demon of the Sky
	Spinning Day and Night		Orion the Giant
	The Earth Is a Ball		The Tale of the Seven Stars
	The Earth is Round!		The Sad Story of the Three Siblings
	Earth Model		The Moon's Shame
	Daytime Telescope		The Eyes of Saint Lucia
	Creating Eclipses in the Classroom		Tales of Wandering Stars
	Dr. Seahorse Creates Rainbows		The Birth of Venus
	Dr. Seahorse Sees the Invisible		Hercules, the Strongest and Bravest
	Making a refractory telescope	**Arts and Immagination**	Shadow Puppets
	Model of a Black Hole		Icosa-Planet
	Safe Sun Viewer		What Does The Full Moon Look Like
	Spicy Solar System		Colouring the Earth
	Dr. Seahorse Sees Spots		Astro-Origami
	Poster: Distances in the Universe		Five Pointed Star Origami
	Make a Reflective Telescope		Crash Landing Moon
	Telescope Basics		Day and Night Colouring
	Universe in a Box		Solar System Song Words
Games	Power Planets Card Game		The Big Universe Song
	Astronomy Snakes and Ladders		Deadly Moons
	DIY Board Game: Light's Journey		Design Your Alien
Helpful Skills and Tools	Astronomy Software		Paper Plates: Moons
	Dr. Seahorse Searches for Polaris		Solar System Passport
	Play With Your Shadow		Super Saturn Arts and Craft
	The Universe in One Hour		Your Birthday on Another Planet

Figura B.1: List of UNAWE' s educational activities.

Appendice C

Example of Activity

CODE	eu-unawe1308
TITLE	Model of a Black Hole
LEVEL AND/OR MINIMUM AGE	Primary School, Ages 8-10
TIME	1h
INDIVIDUAL/GROUP	Group
SUPERVISED/UNSUPERVISED	Supervised
COST	Average (5–25 EUR)
INDOORS/OUTDOORS	Indoors, Outdoors
LANGUAGE	English
BRIEF DESCRIPTION	Many children have heard of black holes and have the understanding that they are bottomless wells. If something falls into a black hole, it is impossible for it to escape — even light cannot escape and is swallowed. That is how a black hole gets its name; it is a point in space that does not give out any light. It is not easy to explain black holes in simple terms, but this experience will help children visualize the concept.
KEYWORDS	Black holes, Gravity, Space, Time, Mass, Interactive, Model.
MATERIALS	Light elastic bandage used for muscular injuries (i.e. Tubifix) Small marble Very heavy ball (such as those used in games of boules, bocce or pétanque)
LAEARNING OBJECTIVES	Use an interactive, hands-on activity to introduce children to the important astronomical concepts of black holes, gravity and space-time Build a physical model of the space curvature around an object and observe the effect of a less massive object Demonstrate what happens to the passing object if its velocity is not high enough, or if the gravity well is deep enough
BACKGROUND INFORMATION	A black hole is a region in space in which gravity is so strong that nothing that enters it, not even light, can escape. Black holes form when a star runs out of fuel and becomes unable to support its heavy outer layers of gas. If the star is large enough—approximately 25 solar masses—then gravity pulls on the gas and causes the star to grow smaller and smaller until its density reaches infinity at a single point. This is called a 'singularity'. After the black hole forms, it can continue to grow by absorbing mass from its surroundings, such as other stars and other black holes. If a black hole absorbs enough material, it can become a ‘supermassive black hole’, which means it has a mass greater than one million solar masses. It is believed that supermassive black holes exist in the centres of many galaxies, including the Milky Way. A black hole is made up of three parts: the singularity (the collapsed star), the ‘inner event horizon’ (the region around the singularity where nothing, not even light, can escape), and the ‘outer event horizon’ (where objects will still feel the gravity of the black hole but not become trapped). Astronomers usually observe objects in space by looking at the light (e.g. how they study stars). However, since black holes don’t emit any light, they can’t be observed in the usual way. Instead, astronomers have to observe the interaction between the black hole and other objects. One way is to observe the motions of stars around the black hole since their orbits will be altered by its presence.
INTRODUCTION	In the following activity, students will build a model of a black hole, which is intended to help them visualize how exactly a black hole can “bend” space and time and affect nearby objects. The activity should take about one hour.
COCLUSION	
ADDITIONAL INFORMATION	Follow-up questions What happens when you decrease the speed of the marble? Why? What happens when you use a heavier ball? What about a heaver marble? How would you be able to know if there is a black hole somewhere by observing the motions of the stars? Resources Accessible information about black holes from the ‘Ask an Astromer’ site at Cornell University. It provides answers to many different questions and specifies difficulty level (beginner, intermediate, advanced): http://curious.astro.cornell.edu/blackholes.php. A video by the European Southern Observatory showing real data taken of stars orbiting around a black hole: http://www.eso.org/public/videos/eso0846a/. A great interactive site from the Space Telescope Science Institute with extensive information about black holes as well as online activities and experiments: http://hubblesite.org/explore_astronomy/black_holes/.
EVALUATION AND ASSESSMENT	
CONNECTION TO CURRICULUM	
SOURCE/ADAPTED FROM/RELATED ACTIVITIES/AUTHOR	
COPYRIGHTS	Attribution-ShareAlike

RESOURCE DESCRIPTION	Steps 1. Cut a ~40 × 40 cm piece of elastic bandage. If it is tubular, you will need to cut it through one side to make it flat. (Image 1) 2. Ask several students to stretch the bandage horizontally until it becomes taut to represent two-dimensional 'space'. 3. Place the marble on the bandage and make it roll across the surface of the bandage. Its path should follow a straight line similar to that of a ray of light travelling through space. 4. Place the heavy ball on the bandage and you will see how it deforms the fabric of 'space'. 'Space' becomes curved around the heavy object. (Image 2) 5. Make the same little marble roll close the heavy object. Its trajectory should now be altered by the deformation of the bandage. This is similar to what happens to light passing close to a massive object that deforms the space surrounding it. Try varying the speed of the marble to see how its path changes. (Image 3) 6. The more concentrated the central mass (i.e. the heavier the large ball), the more curved the bandage will be. This increases the depth of the 'gravitational well' from which the marble will not be able to escape. (Image 4) 7. As the marble passes close to the large ball, it starts to revolve around the 'black hole' and eventually falls in. Once it is there, you can see how things may easily fall into a black hole but cannot come back out. This is what happens with black holes: their gravity deforms space in such a way that light or other objects fall in and cannot escape.
ATTACHMENTS	Images of the different steps of the activity: Images 1-4

Figura C.1: Structure model of Model of a Black Hole activity.

CODE

eu-unawe1308

TITLE

Model of a Black Hole

LANGUAGE

English

TIME

1hour

LEVEL AND MINIMUM AGE

Primary School, Ages 8-10

COST

Average (5–25 EUR)

BRIEF DESCRIPTION

Many children have heard of black holes and have the understanding that they are bottomless wells. If something falls into a black hole, it is impossible for it to escape — even light cannot escape and is swallowed. That is how a black hole gets its name; it is a point in space that does not give out any light. It is not easy to explain black holes in simple terms, but this experience will help children visualize the concept.

KEYWORDS

- Black holes
- Gravity
- Space
- Time
- Mass
- Interactive
- Model

MATERIALS

- Light elastic bandage used for muscular injuries (i.e. Tubifix)
- Small marble
- Very heavy ball (such as those used in games of boules, bocce or pétanque)

LEARNING OBJECTIVE

- Use an interactive, hands-on activity to introduce children to the important astronomical

concepts of black holes, gravity and space-time
- Build a physical model of the space curvature around an object and observe the effect of a less massive object
- Demonstrate what happens to the passing object if its velocity is not high enough, or if the gravity well is deep enough

BACKGROUND INFORMATION

A black hole is a region in space in which gravity is so strong that nothing that enters it, not even light, can escape. Black holes form when a star runs out of fuel and becomes unable to support its heavy outer layers of gas. If the star is large enough—approximately 25 solar masses—then gravity pulls on the gas and causes the star to grow smaller and smaller until its density reaches infinity at a single point. This is called a 'singularity'.

After the black hole forms, it can continue to grow by absorbing mass from its surroundings, such as other stars and other black holes. If a black hole absorbs enough material, it can become a 'supermassive black hole', which means it has a mass greater than one million solar masses. It is believed that supermassive black holes exist in the centres of many galaxies, including the Milky Way.

A black hole is made up of three parts: the singularity (the collapsed star), the 'inner event horizon' (the region around the singularity where nothing, not even light, can escape), and the 'outer event horizon' (where objects will still feel the gravity of the black hole but not become trapped).

Astronomers usually observe objects in space by looking at the light (e.g. how they study stars). However, since black holes don't emit any light, they can't be observed in the usual way. Instead, astronomers have to observe the interaction between the black hole and other objects. One way is to observe the motions of stars around the black hole since their orbits will be altered by its presence.

ACTIVITY FULL DESCRIPTION

Introduction

In the following activity, students will build a model of a black hole, which is intended to help them visualize how exactly a black hole can "bend" space and time and affect nearby objects. The activity should take about one hour.

Steps

1. Cut a ~40 × 40 cm piece of elastic bandage. If it is tubular, you will need to cut it through one side to make it flat. (**Image 1**)
2. Ask several students to stretch the bandage horizontally until it becomes taut to represent two-dimensional 'space'.
3. Place the marble on the bandage and make it roll across the surface of the bandage. Its path should follow a straight line similar to that of a ray of light travelling through space.
4. Place the heavy ball on the bandage and you will see how it deforms the fabric of 'space'. 'Space' becomes curved around the heavy object. (**Image 2**)
5. Make the same little marble roll close the heavy object. Its trajectory should now be altered by the deformation of the bandage. This is similar to what happens to light passing close to a massive object that deforms the space surrounding it. Try varying the speed of the marble to see how its path changes. (**Image 3**)

6. The more concentrated the central mass (i.e. the heavier the large ball), the more curved the bandage will be. This increases the depth of the 'gravitational well' from which the marble will not be able to escape. (**Image 4**)
7. As the marble passes close to the large ball, it starts to revolve around the 'black hole' and eventually falls in. Once it is there, you can see how things may easily fall into a black hole but cannot come back out. This is what happens with black holes: their gravity deforms space in such a way that light or other objects fall in and cannot escape.

ADDITIONAL INFORMATION

Follow-up questions

- What happens when you decrease the speed of the marble? Why?
- What happens when you use a heavier ball? What about a heaver marble?
- How would you be able to know if there is a black hole somewhere by observing the motions of the stars?

Resources

Accessible information about black holes from the 'Ask an Astromer' site at Cornell University. It provides answers to many different questions and specifies difficulty level (beginner, intermediate, advanced):
http://curious.astro.cornell.edu/blackholes.php.

A video by the European Southern Observatory showing real data taken of stars orbiting around a black hole:
http://www.eso.org/public/videos/eso0846a/.

A great interactive site from the Space Telescope Science Institute with extensive information about black holes as well as online activities and experiments:
http://hubblesite.org/explore_astronomy/black_holes/.

ATTACHMENTS

Images of the different steps of the activity: **Images 1-4**

Activity for groups to do while supervised indoors or outdoors.

Figura C.2: Revision of structure model to allow any small corrections and additions.

8-10

1h

PRIMARY SCHOOL

Model of a Black Hole

EU UNIVERSE AWARENESS ACTIVITY

EN

BRIEF DESCRIPTION

Many children have already heard of black holes, with the understanding that they are bottomless wells. If something falls into a black hole, it is impossible for it to escape — even light cannot escape and is swallowed. That is how a black hole gets its name; it is a point in space that does not give out any light. It is not easy to explain black holes in a simple way, but this experience will help children visualize the concept.

KEYWORDS

- *Black holes*
- *Gravity*
- *Space*
- *Time*
- *Mass*
- *Interactive*
- *Model*

MATERIALS

- *Large elastic bandage, used for muscular injuries (i.e. Tubifix, sold in chemists)*
- *Small marble*
- *Very heavy ball (such as those used in games of Boules, Bocce or Pétanque)*

LEARNING OBJECTIVE

- *Use an interactive, hands-on activity to introduce children to the important astronomical concepts of black holes, gravity and space-time,*
- *Build a physical model of the space curvature around an object and observe the effect of a less massive object*

passing close to it,
- Demonstrate what happens to the passing object if its velocity is not high enough, or if the gravity well is deep enough.

BACKGROUND INFORMATION

A black hole is a region in space where gravity is so strong that nothing that enters it, not even light, can escape. They form when a star runs out of fuel and becomes unable to support its heavy outer layers of gas. If the star is large enough — about 25 solar masses — then gravity pulls on the gas and causes the star to grow smaller and smaller until its density reaches infinity at a single point. This is called a 'singularity'.

After the black hole forms, it can continue to grow by absorbing mass from its surroundings, such as other stars and other black holes. If a black hole absorbs enough material, it can become a "supermassive black hole", which means it has a mass of over one million solar masses. It is believed that supermassive black holes exist in the centers of many galaxies, including the Milky Way.

A black hole is made up of three parts: the singularity (the collapsed star), the 'inner even horizon' (the region around the singularity where nothing, not even light, can escape), and the 'outer event horizon' (where objects will still feel the gravity of the black hole, but not become trapped).

Usually, astronomers observe objects in space by looking at the light (for example, that is how they study stars). However, since black holes don't emit any light, they can't be observed in the usual way. Instead, astronomers have to observe the interaction of the black hole with other objects. One way is to observe the motions of stars around the black hole, since their orbits will be altered by its presence. Additionally, quantum mechanics predicts that black holes emit radiation like a blackbody with temperature proportional to the black hole surface density, and inversely proportional to the black hole mass. However, observations of this radiation are difficult for black holes of masses greater than one solar mass.

FULL ACTIVITY DESCRIPTION

In the following activity, students will build a model of a black hole, which is intended to help them visualize how exactly a black hole can "bend" space time, and effect nearby objects. The activity should take about one hour.

STEP 1

Cut a ~40cm piece of elastic bandage. If it is tubular, you will need to cut it through one side in order to make it flat.

STEP 2

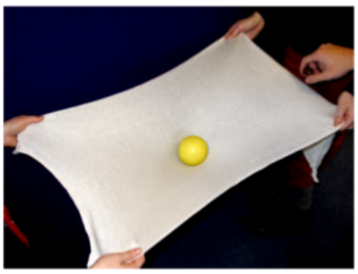
Ask several students to stretch the bandage horizontally, until it becomes taut, to represent two-dimensional 'space'.

STEP 3

Place the marble on the bandage and make it roll across the surface of the bandage. Its path should follow a straight line, similar to that of a ray of light traveling through space.

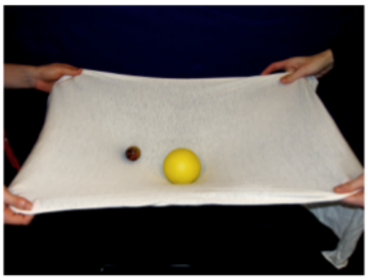
STEP 4

Place the heavy ball on the bandage and you will see how it deforms the fabric of 'space'. 'Space' becomes curved around the heavy object.



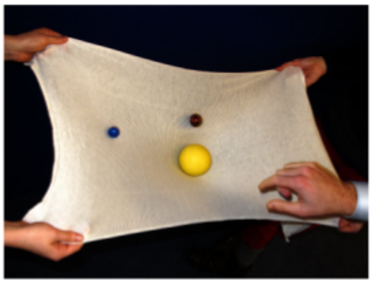
STEP 5

Make the same little marble roll close the heavy object. Its trajectory should now be altered by the deformation of the bandage. This is similar to what happens to the light passing close to a massive object that deforms the space surrounding it. Try varying the speed of the marble to see how its path changes.



STEP 6

The more concentrated the central mass (that is, the heavier the large ball), the more curved the bandage will be. This increases the depth of 'gravitational well', from which the marble will not be able to escape.



ADDITIONAL INFORMATION

Follow-up questions

- *What happens when you decrease the speed of the marble? Why?*
- *What happens when you use a heavier ball? What about a heaver marble?*
- *How would you be able to know if there is a black hole somewhere by observing the motions of the stars?*

Resources

Accessible information about black holes from the Ask an Astromer site at Cornell University. Has answers to many different questions with difficulty level (beginner, intermediate, advanced) specified.

http://curious.astro.cornell.edu/blackholes.php

A video by the European Southern Observatory showing real data taken of stars orbiting around a black hole.

http://www.eso.org/public/videos/eso0846a/

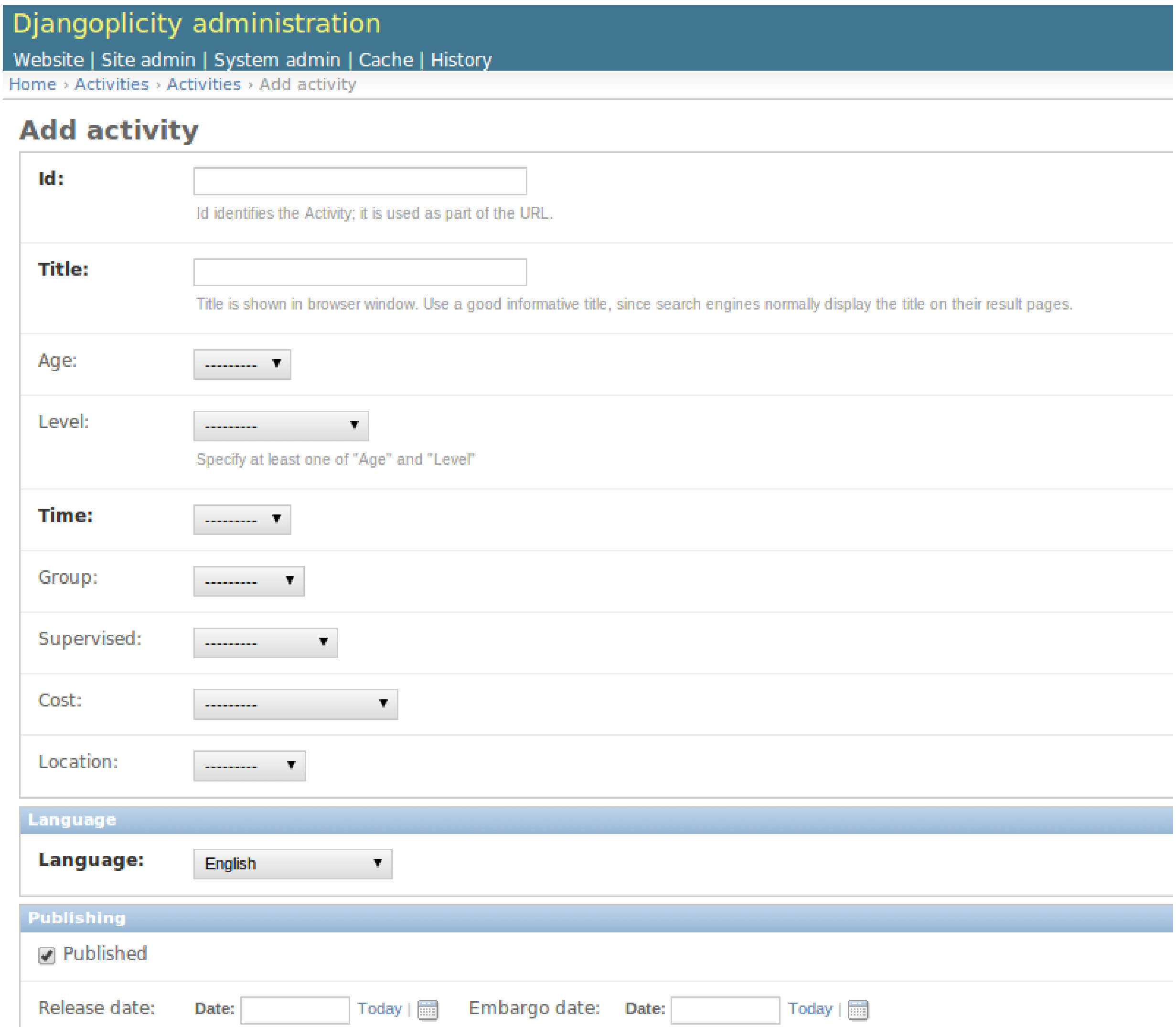
A great interactive site from the Space Telescope Science Institute with lots of information about black holes, as well as online activities and experiments.

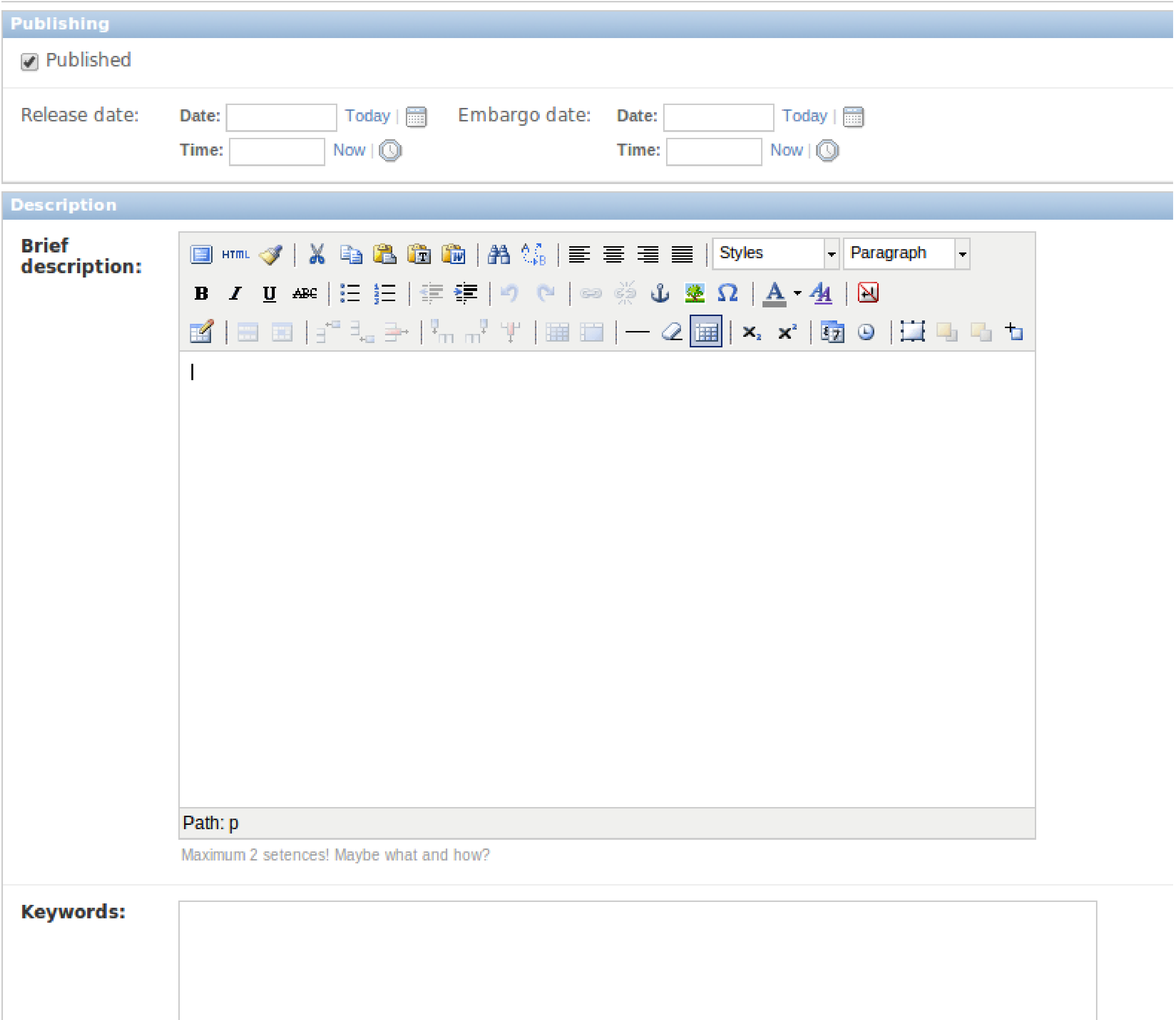
http://hubblesite.org/explore_astronomy/black_holes/

Figura C.3: Final result for Model of a Black Hole.

Appendice D

Submission

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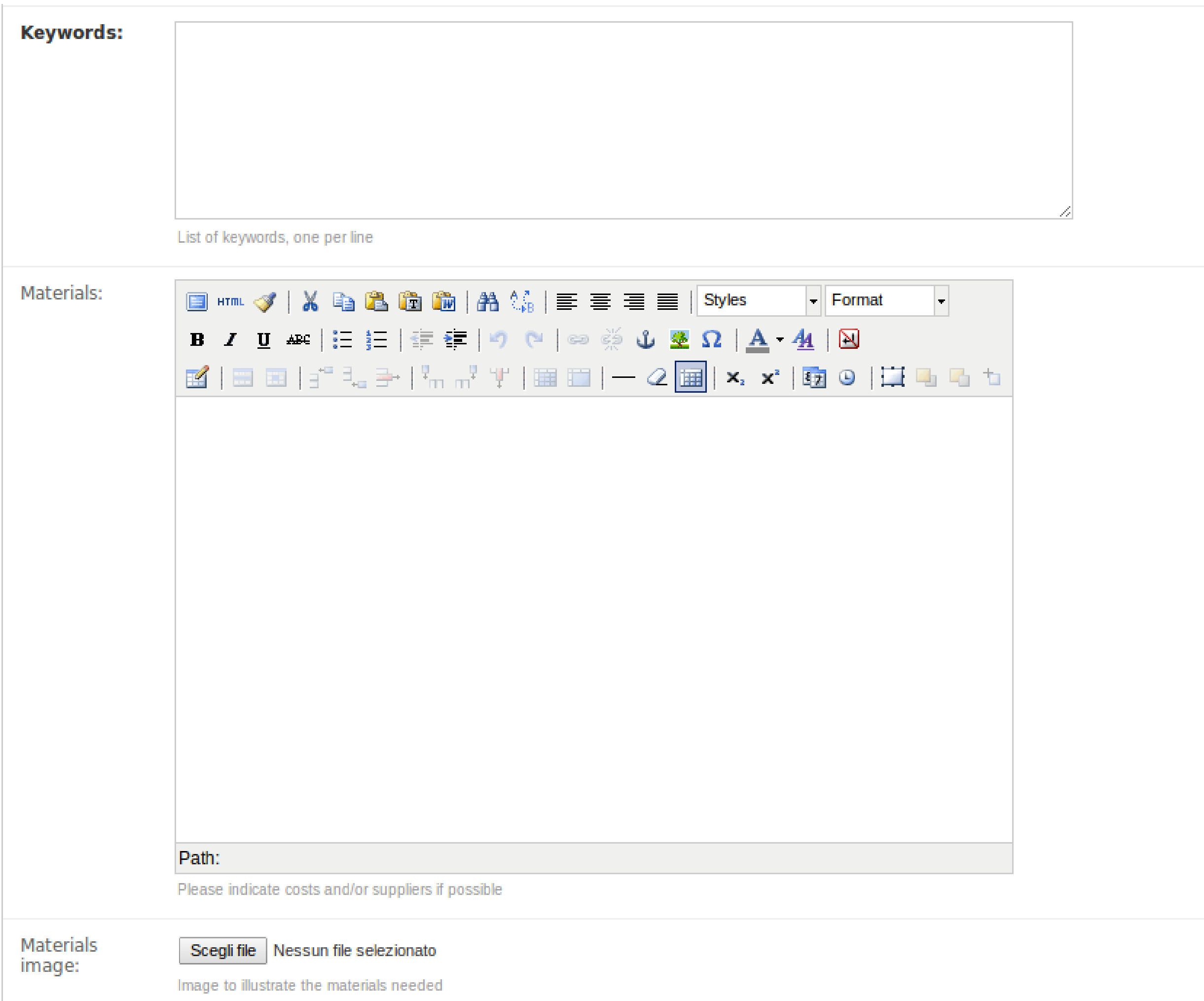
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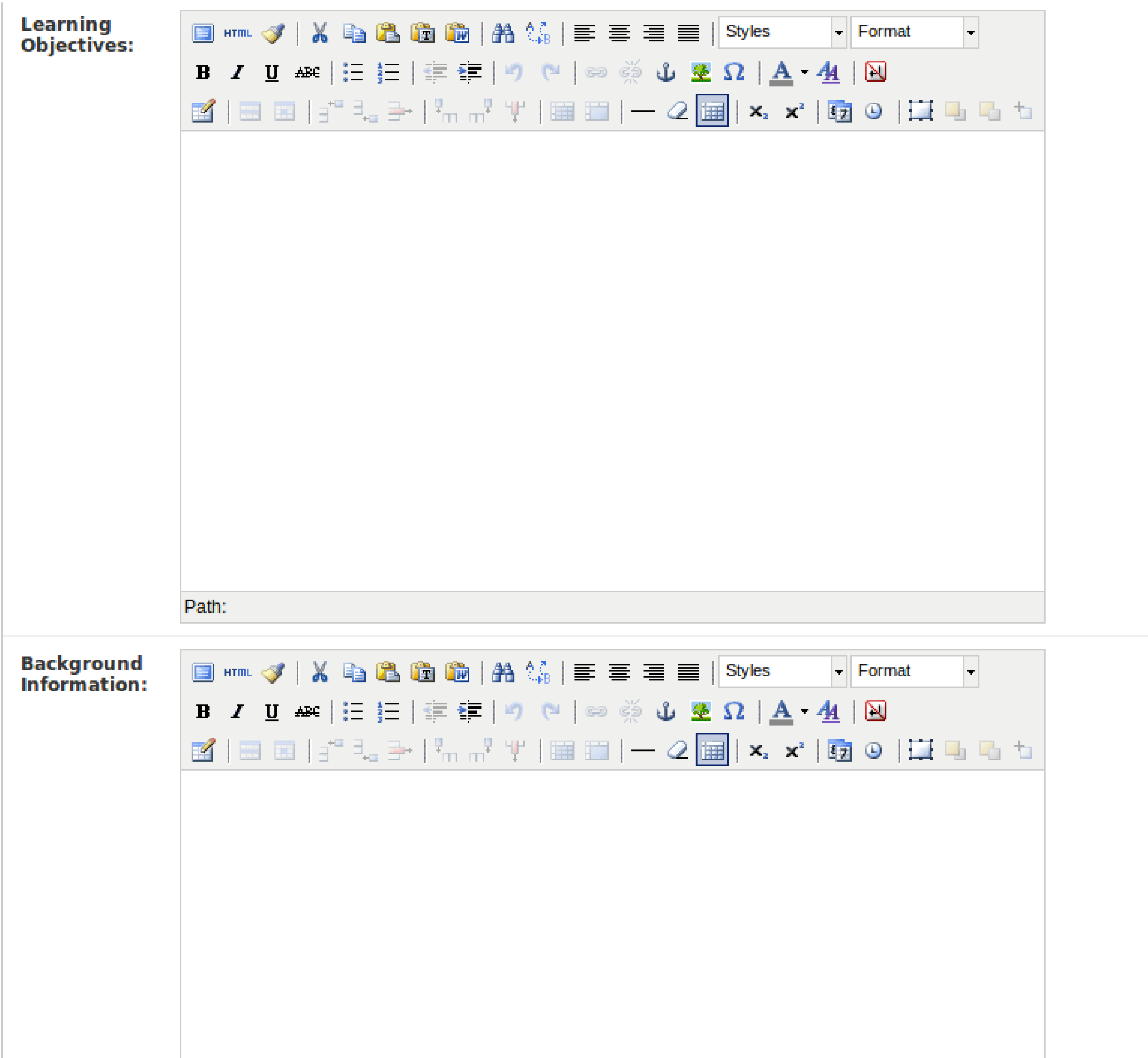
Image to illustrate the materials needed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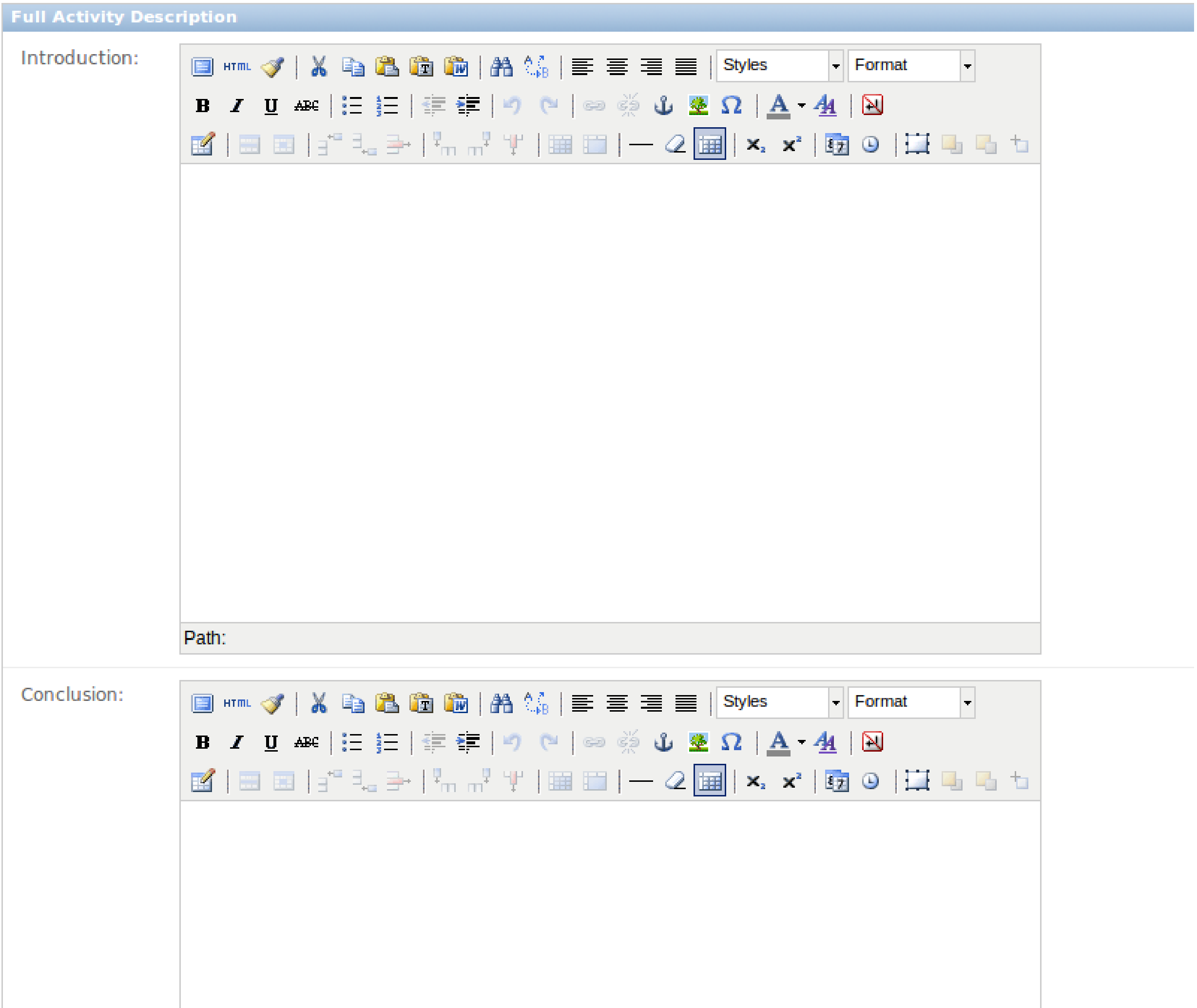
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Format
Path:
Conclusion:
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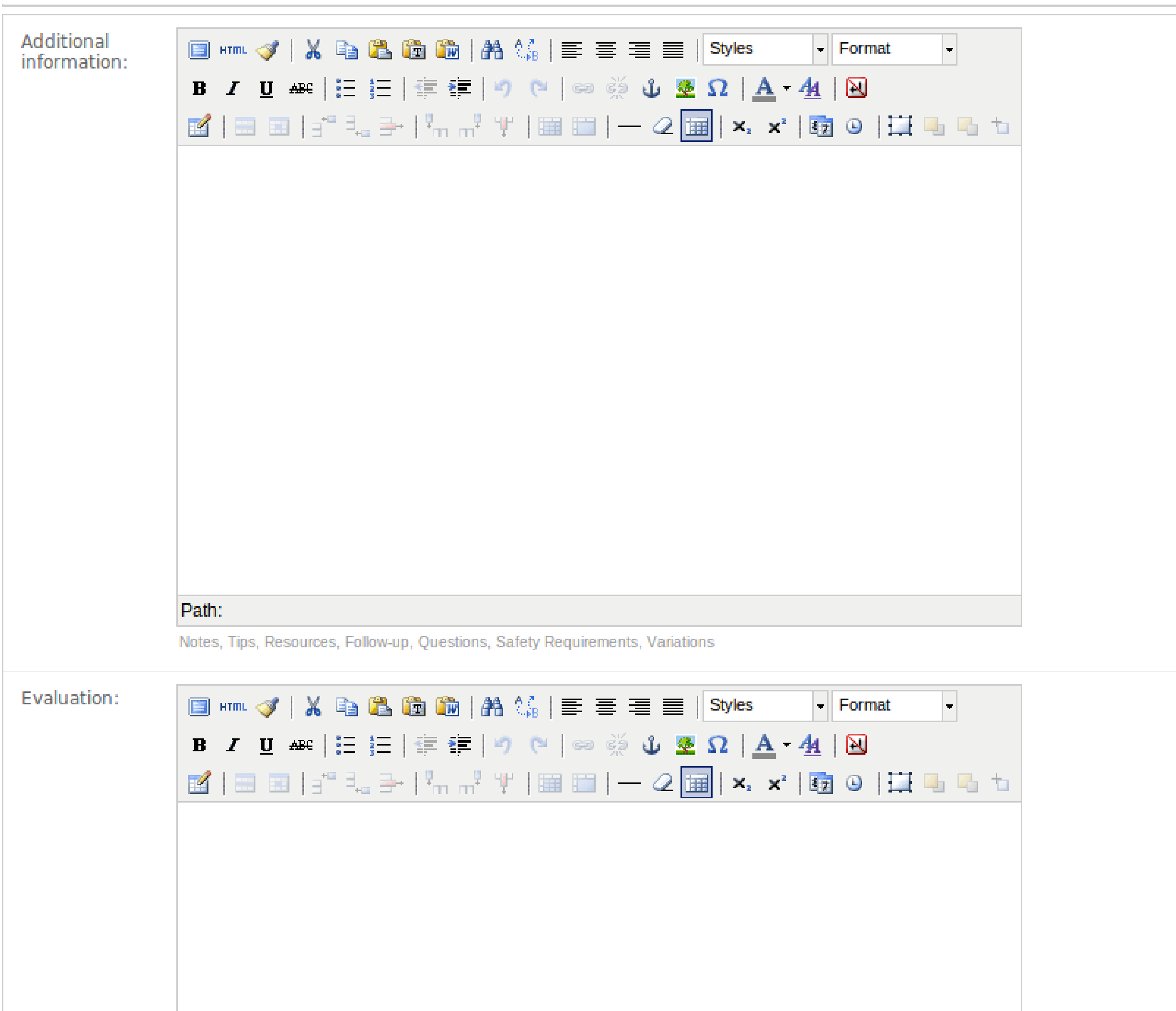
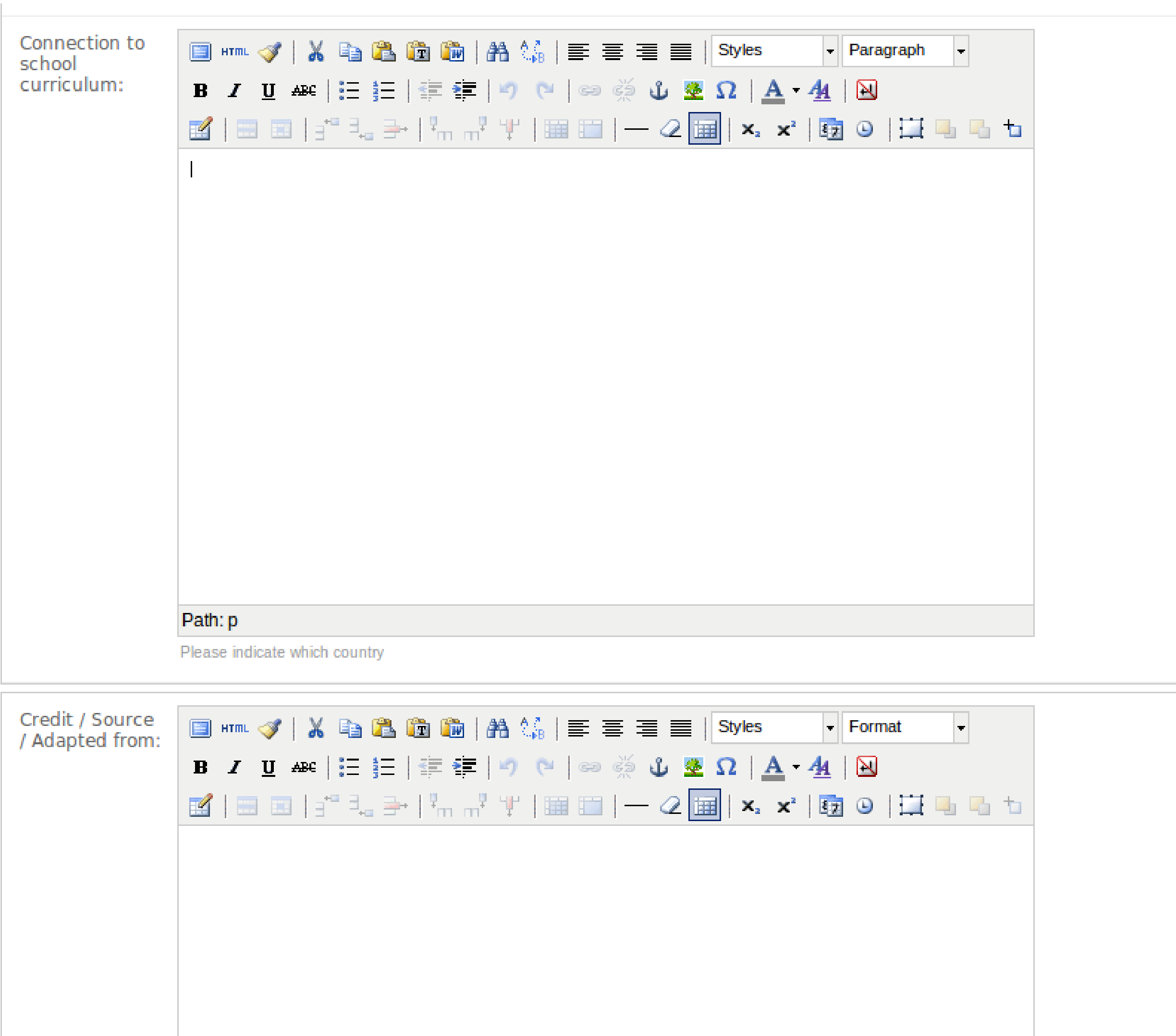
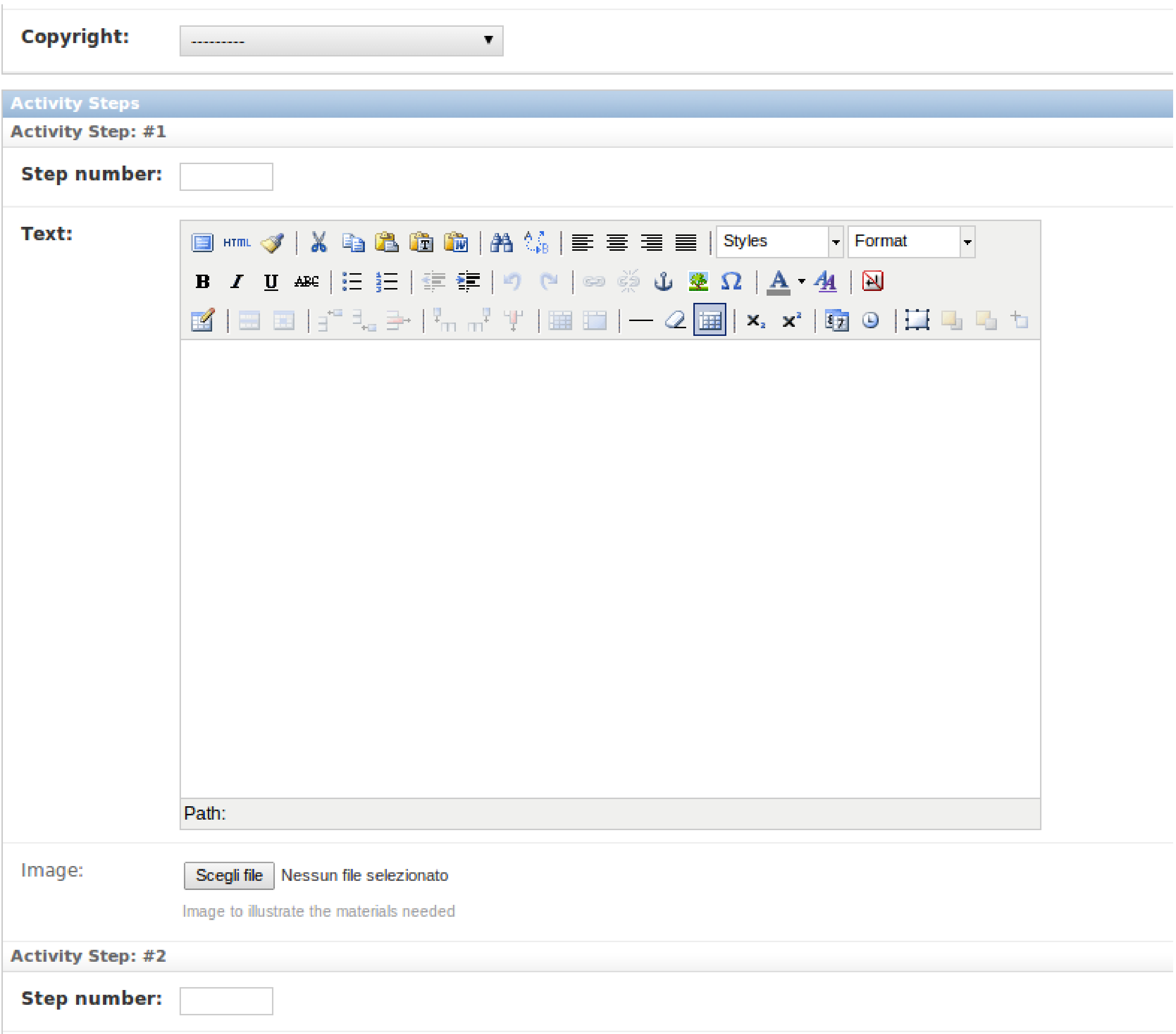

Additional information:
HTML
Styles
Format
Path:
Notes, Tips, Resources, Follow-up, Questions, Safety Requirements, Variations
Evaluation:
HTML
Styles
Format


Connection to school curriculum:
HTML
Styles
Paragraph
Path: p
Please indicate which country
Credit / Source / Adapted from:
HTML
Styles
Format


Copyright:

Activity Steps
Activity Step: #1
Step number:
Text:
Styles
Format
Path:
Image:
Scegli file
Nessun file selezionato
Image to illustrate the materials needed
Activity Step: #2
Step number:

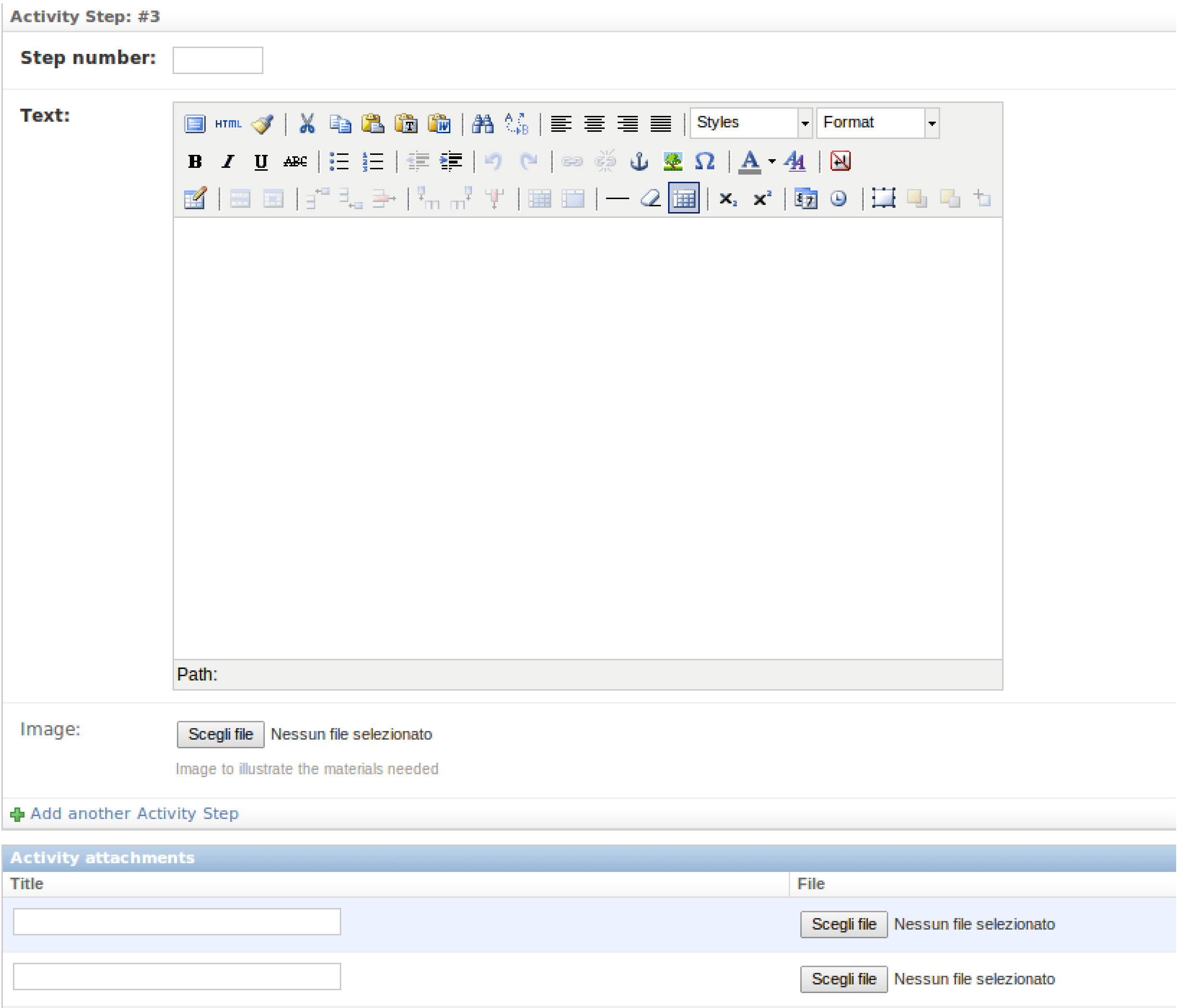


Figura D.1: Example of a complete submission form for the activities.

Appendice E

Data Collection Instruments

Uses, Benefits, and Limitations of Various Data Collection Instruments

Instruments	Overall Purpose	Advantages	Challenges
Interviews	To fully understand someone's impressions or experiences, or learn more about their answers to questionnaires.	• Provides full range and depth of information • Develops relationship with respondent • Allows for follow-up questions	• Can take much time • Can be hard to analyze and compare • Can be costly • Interviewers can bias responses • Generalization is limited
Focus Groups	To explore a topic in depth through group discussion, e.g., about reactions to an experience or suggestion, understanding common complaints. Useful in evaluation and marketing.	• Quickly and reliably obtain common impressions • Can be efficient way to gather range and depth of information in short time • Can convey key information about projects	• Can be hard to analyze responses • Need a good moderator to steer the discussion and provide closure • Difficult to schedule 6-8 people together • Strong individuals may influence others' responses
Questionnaires and surveys	To quickly and/or easily obtain a lot of information from people in a non-threatening way.	• Can complete anonymously • Inexpensive to administer • Easy to compare and analyze • Can administer to many people • Can obtain lots of data • Many sample questionnaires already exist	• Might not get careful feedback • Wording can bias client's responses • Impersonal • In surveys, may need sampling and statistical expertise • Doesn't yield full story
Observation	To gather accurate information about how a project actually operates, particularly about processes.	• Can view operations of a project as they are actually occurring • Can adapt to events as they occur	• Can be difficult to interpret behaviors • Observations can be difficult to categorize • Can influence participant's behaviors • Can be expensive
Literature Review	To gather information on the audience and/or the issue. Identify what previous investigations have found about the knowledge, skills, behaviors, or attitudes of the intended audience with relation to the issue.	• Can provide much information in relatively little time • Makes use of already gathered information • Helps to sort changes over time • Provides evidence about the problem • Minimum effort or interruption of audience	• Can be out-of-date (e.g., technology needs) • Data synthesis can be difficult • May not address specific questions of concern • Not a flexible means to get data; data restricted to what already exists • Statistical data may not address perceptions of the problem, or may not address causes of the problem • Reports may be incomplete

Tests	To determine the audience's current state of knowledge or skill regarding the issue.	• Helps identify a problem or a deficiency in knowledge or skills • Results are easily quantified • Individual performances can be easily compared	• Limited availability of validated test for specific situations • Language or vocabulary can be an issue • People may be concerned about how results will be used • Adults may resent taking tests
Concept Maps	To gather information about someone's understanding of, and attitudes towards, a complex subject or topic.	• Can offer a more comprehensive and complex view of someone's thinking than a test does • Could be a better tool for visual learners or test-phobic people • Produces qualitative and quantitative data	• Takes training to complete properly • Takes training to administer • Can be challenging and time consuming to score • Can be difficult to analyze and interpret
Document or Product Review	To gather information on how the project operates without interrupting the project; comes from review of applications, finances, memos, minutes, etc.	• Yields historical information • Doesn't interrupt project or client's routine in project • Information already exists • Few biases about information	• Often takes much time • Information may be incomplete • Need to be quite clear about what one is looking for • Not a flexible means to obtain data; data restricted to what already exists
Case Studies or Peer Review	To fully understand or depict client's experiences in a project; to conduct comprehensive examination through cross comparison of cases.	• Fully depicts client's experience in project input, process, and results • Powerful means to portray project to outsiders	• Usually quite time consuming to collect, organize, and describe • Represents depth of information, rather than breadth • Information gathered represents a single individual or event; cannot be generalized

Figura E.1: List of the various data collection instruments with their uses, benefits and limitation. Source: McNamara, C. *Basic guide to programme evaluation*, 2003.

A. Method versus Audience

Evaluation Methods* *Audience*	**Interview**	**Focus Group**	**Survey**	**Observation**	**Test**	**Concept Maps**	**Case Study**
Adults/who know you or your organization	Good	Good	Good	Good	Good	Good	Good
Adults/who don't know you or your organization	Good	Good	Good		Fair to Poor	Good to Fair	Fair
Decision-makers/ policy makers/ community leaders	Good	Fair	Good to Fair	Good to Fair	Good to Fair	Fair	Good
Cultural groups (otherthan your own)	Fair to Poor	Good to Fair	Fair to Poor	Good to Fair	Poor	Good to Fair	Fair to Poor
Teachers	Good	Good	Good	Good	Fair	Fair	Good
Teens	Good	Fair	Fair	Fair	Fair	Good	Good
Eight to twelve year olds	Fair	Fair	Fair	Fair	Fair	Good	Fair
Three to seven year olds	Fair to poor	Fair to poor	N/A	Good	N/A	N/A	Fair to poor

Figura E.2: Method Versus Audience. Rating scale: Good = offers more benefits than limitations; Fair = benefits and limitations are close to even; Poor = offers more limitations than benefits; N/A = tool in most cases is not appropriate for the audience.

B. Method versus Activity/Project

Evaluation Method*	**Interview**	**Focus Group**	**Survey**	**Test**	**Observation**	**Concept Map**
Project/Activity						
Talk/lecture (short, single event)	Poor	Poor	Fair	Good to Fair	Poor	Fair
Workshop (single event)	Fair	Fair	Good	Good	Poor	Good to Fair
Series (multiple meetings)	Good	Fair	Good	Good	Fair	Good
Training (skill building)	Good	Good	Fair	Fair	Good to Fair	Fair
Tour (adults)	Good	Fair	Fair	Fair	Fair	Fair
Tour (3-16 year olds)	Fair	Fair	Poor	Poor	Fair to Poor	Fair
Event/festival	Good	Fair	Good	N/A	Fair	N/A
Interpretive sign(s)	Good	Fair	Fair	Fair	Good to Fair	N/A
Exhibit	Good	Good	Good	Fair	Good to Fair	Good
Curriculum packet/materials	Good	Fair	Good	Fair	Fair	Good
Kits/activities	Good	Fair	Good	Fair	Fair	Good
Publications	Good	Fair	Fair	Fair	Poor	Poor
Media (e.g., video)	Good	Good	Good to Fair	Fair	N/A	Fair
Interactive media (e.g., CD)	Good	Good	Good to Fair	Fair	Good	Good
Website	Good	Fair	Good to Fair	Fair	Good	Good

Figura E.3: Method Versus Activity/Project. Rating scale: Good = offers more benefits than limitations; Fair = benefits and limitations are close to even; Poor = offers more limitations than benefits; N/A = tool in most cases is not appropriate for the audience.

Appendice F

UNAWE Data Gathering Tools

PMM
Personal meaning map
template to photocopy

EU UNIVERSE AWARENESS

Name: ____________

Pretends it is night! Draw the sky. What do you see?

Date .... **Location** ....

Activity being evaluated ....

Child age ....**M / F Languages:**.......................

School..

Instructions:

Children add ideas as writing or drawing, pre activity, using a pencil. After their activity, return and add new ideas using a PEN or BLUE coloured pencil

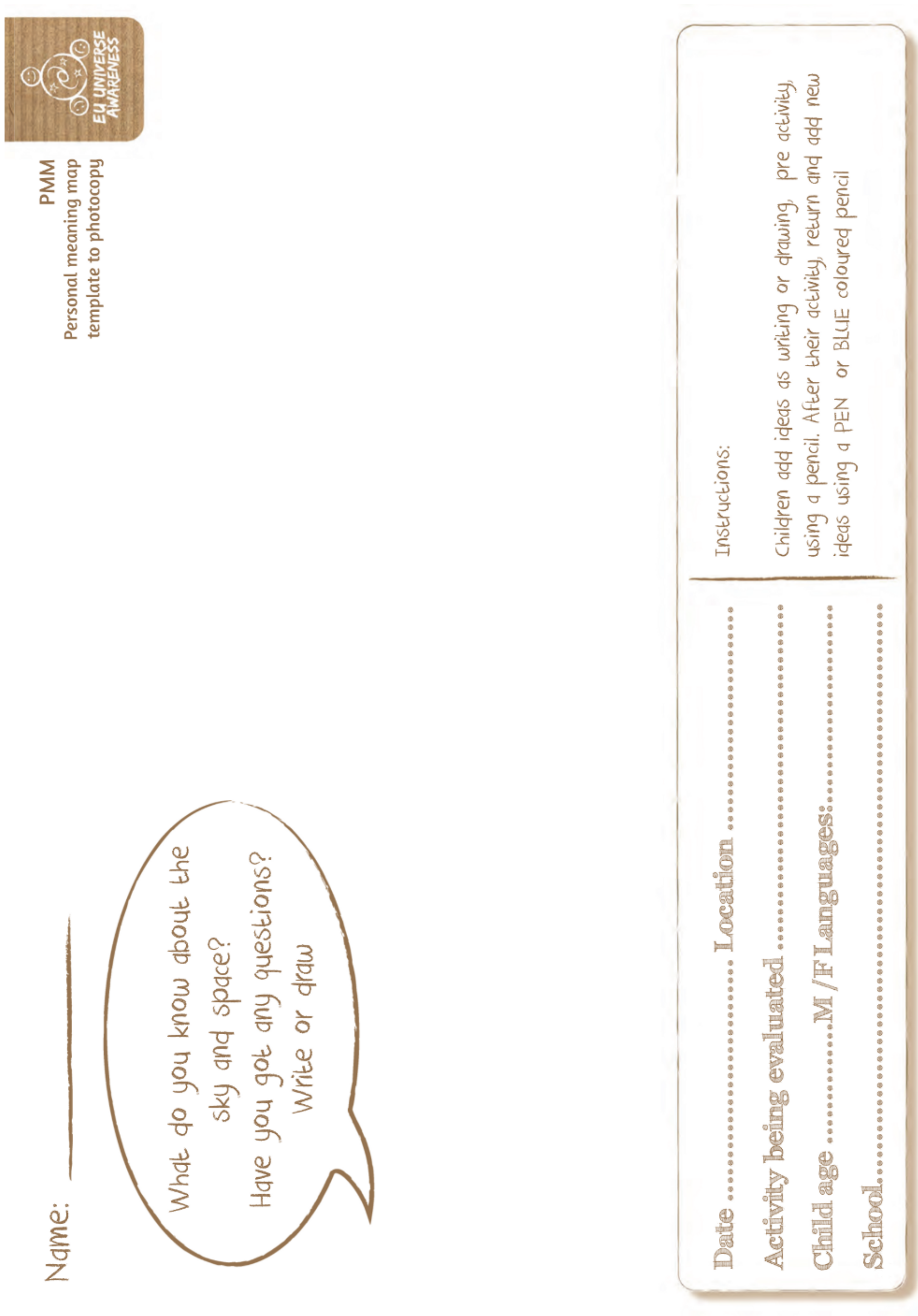


Figura F.1: Personal Meaning Map (PMM) Templates.

Child observation template (4-7 years)

Name of observer: ……………………………Location: ………………………

Date of observation: ……………………………Time: ………………………

Activity being evaluated:………………………………………………

Child age…………M/F Languages:……………………………………

School…………………………………………………………

	Tally / score (e.g. III)	Total	Evidence (e.g. "smiled on seeing moon"
Motivation			
Scientific Skills			
Knowledge			
International Attitudes			

12 Submit information online: **http://goo.gl/2eFfW**

Figura F.2: Children Observation Templates (4-7 years).

Pupil survey (8-10 years)

Name: .... Date: ....

School: ....

Teacher: .... Age: ....

1 What activities have you done in class about space?

2 What did you enjoy about this topic?

3 Is there anything you did not like?

4 Would you like to find out more about astronomy and space in future?

5 Have you got any questions about space?

6 If you were going to make a Space Museum or a space display for your class, what topics and objects would you put in?

Write or draw to explain your plan.
Work on the back of this paper.

13

Figura F.3: Pupil Survey (8-10 years).

Evaluation materials
Astro-Cards classification games

Card game "Astro-Cards": Identification and classification game of astronomical objects.

Exercise 1

Age: 8

Materials: Card set "Astro-families" (24 cards)

Goal: Evaluate children´s awareness of the existence of different astronomical objects and of the place of the Earth among them by asking them just to identify those that they know and to name them. In doing so, children can group them in families (planets, comets, stars, nebula, constellations, galaxies, etc).

Link to Astronomy and scientific skills:

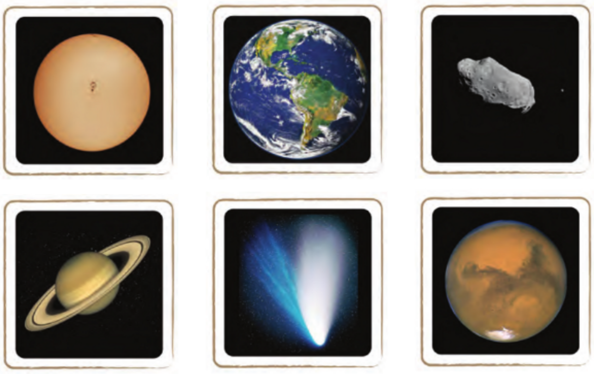
Astronomy relies strongly on the observation, identification and posterior classification of objects into family classes, and on their location in space at different scales and distances. Observation and classification skills play therefore a key role.

Astro-cards evaluation games

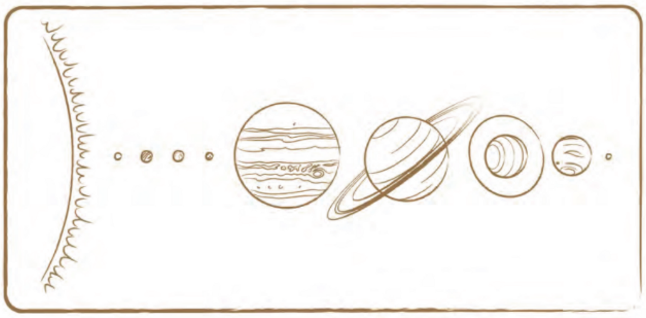
Exercise 2

Identification of objects belonging to the Solar System

Ask children to identify some objects among the cards belonging to the Solar System.



Objects belonging to the Solar system



Link to Astronomy and scientific skills:

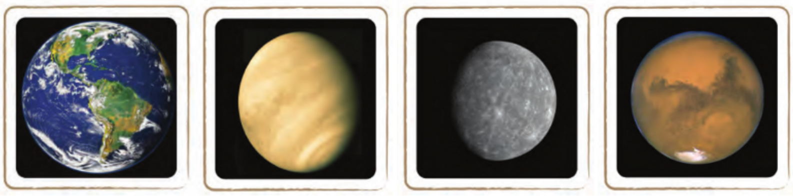
To learn about our cosmic adress and our neighbourhood it is important that children gain a idea of all objects belonging to the Solar System

Astro-cards evaluation games

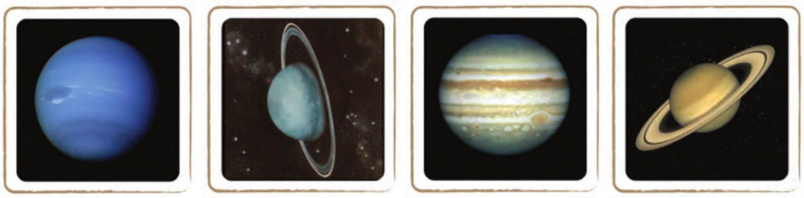
Exercise 3

Identification and classification of planets

Ask children to identify among the cards the planets , to name them and group them into solid and gaseous planets according to their distances to the Sun.



The solid planets of the Solar System



Gaseous planets

Link to Astronomy and scientific skills:

The distinktion between solid (rocky) and gaseous, and their distance to the Sun planets plays an important role when discussing the habitability of planets. Therefor is this classification fundamental of the discussion about life in the Solar System. Also, the uniqueness of the Earth among the planets can only be understood in this classification context.

Astro-cards evaluation games

Exercise 4

Identification and classification of asteriods and comets

Ask children to identify among the cards the asteroids and comets and to discuss about their differences and location in the Solar System.






Link to Astronomy and scientific skills:

Both asteroids and comets are considered as fossiles objects of the Solar System and are connected to ist formation history. Planets formed in the past from the collisions of hundred of thousands of asteroids which had in turn formed out from dust grains of the protoplanetary disc sorrounding the Sun. Comets are icy objects that, when close enough to the Sun, displays a visible coma (a thin temporary atmosphere) and a tail. It is thought that the Earth water came from lots of comets impacting its surface.

Astro-cards evaluation games

Exercise 5

Identification and classification of nebula and star clusters

Ask children to identify among the cards the nebula (birth place of stars) and the open and globular star clusters.

Astro-cards evaluation games

Exercise 6

Identification and classification of galaxies, galaxy families and galaxy clusters

19

Figura F.4: Evaluation Materials: Astro-Cards Classification Games.

Quick evaluation: Astro-Poster

Another posibility of performing a quick evaluation is to show children the poster bellow and ask them to identify as many objects as possible. In doing so they could describe their size and location (e.g. within the Milky Way, outside the Milky Way).

20

Figura F.5: Quick Evaluation: Astro-Poster.

Teacher workshop survey (page 1/2)

Name: ... ... Date: ... ...
Workshop Location: ... ...Time: ....
Date of teacher workshop:... ... ...
Age of class taught: ... ...School name: ....
School adress:... ... ...
Your email adress: ....
School... ... ...

We would prefer that this is completed online at: **http://goo.gl/XejyP**

About you

1 What did you enjoy about the course?

2 Did you gain knowledge about the universe? Please explain.

3 Did you develop any new skills or practice existing skills?

4 Did the course make you consider cultural perspectives differently?

5 Did you share aspects of this course with other staff? How?

6 Have you got any recommendations for improvements to your course?

7 Have you embedded any new materials into the curriculum as a result of this course?

Teacher workshop survey (page 2/2)

About your pupils

8 How did you interpret the activities for your pupils?

9 What did they enjoy about the activity?

10 Were there any constraints to implementing the activity?

11 What do you think your pupils learnt?

12 Did they have the opportunity to try out any new skills?

13 Did they have opportunities for cultural learning?

14 Which aspects of curriculum assessment did the activities address?

15 Please rate the UNAWE resources out of 10,(10= excellent):

16 How could future projects support opportunities for children to be involved in astronomy?

Any other comments?

24

Figura F.6: Teacher Workshop Survey.

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