1 Introduction

1.1 Introduction

Let me start this book by sharing with you my experience while I was watching the video “The history of technology in Education” by SMART\(^1\). I enjoyed that video very much. Please, watch it, and if you cannot watch it, at least consider Figure 1.1 with one of the snapshots of the video.

![Figure 1.1: A snapshot of the video with its storyline](image)

I imagined myself teaching in the Pythagoras Academy in 510 BCE just talking to my students. I would have questioned them about the purpose of nature, language, music, arts, math, etc. I would have waited until they all had answered and shared their insight and ideas. Later, I felt sad because I imagined that it would have been just 20 students, while most of the population lacked a proper education. Moreover, I felt really sad when I realized that there was no technology, as simple as a notebook or a textbook, so that the students could take and share notes, or even register in some way the knowledge, to transfer and enrich it. If you were not there listening, you missed it!

Later, according to the video (in America), there were the first public schools in 1600. I felt happier because Public Education meant more students who could come to class, and there was basic technology for them: a blackboard, some chalkboard slates and books. But then again, I felt sad, because I imagined I would have made my students repeat a hundred times the same sentences so that they memorized them by heart. Is that the purpose of teaching?

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1 See the video at http://www.youtube.com/watch?v=UFwWWsz_X9s (last visit on June 30\(^{th}\), 2013). I assume basic knowledge of how to use Internet, if not please read Cadenhead (2002) a step-by-step guide to start using Internet.

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Three hundred years later, the audiovisual age started. This was a huge change in general, and as usual, such changes affect education too. So, I imagined myself entering the classroom with my overhead projector, asking the students what they saw, and discussing that with them. I felt happier as a teacher with pedagogical goals, and with some technological advances at hand to enhance the teaching experience. Again, the technology is seen as a tool, and if, as a teacher, you learn how to use it, it can feel really good to have such tools! Moreover, there are other ways for students to gain and share their knowledge: listening to radio programs, watching TV and reading books.

Some researchers tried to use TV as a powerful teaching medium, according to the old Chinese proverb:

Tell me and I’ll forget
show me and I may remember
involve me and I’ll understand

Television makes “showing” possible, it was more than talking and listening, and you could even record the programs with a video recorder, using VHS tapes to watch the programs several times. Even, at the end of the decade, with the first computers, you could start watching some information on your computer screen. Later, it would be possible to record your own CD or DVD and watch it whenever you liked. Can you see a problem with that?

It seems wonderful, but read again the Chinese proverb; we are just at the second line, what happens with the most powerful line: “involve me and I’ll understand”? Watching television or a CD/DVD in your computer are passive activities, you are a spectator whose opinion is not sought. You do not need even to think! You are not asked to get involved, so how can you get involved?

And then, the Internet appeared! It was such a big revolution, first for the military and researchers at universities. They could know what happened far from their home, and they got involved! Researchers thought that the Internet could be the answer for education, too. The Internet provided something new, something that no previous technology had provided, it provided “interaction”. You may be thinking right now, and why is interaction so important?

Well, interaction allows the student to get involved and, according to the Chinese proverb, to understand. If the student is no longer a spectator, but is required to participate, to modify parameters and to change what happens, to introduce new aspects, to answer, to play, then this is the new dimension that technology could provide in a one-to-one personalized setting, as a complement for other teaching methods.

Moreover, new technologies have appeared in the last decades. Hence, in this book, which I am writing with the purpose of helping you become a 21st century teacher with pedagogical goals, I would like to help you understand the technology of this era so that you can use this as a complement to your teaching.
Teachers in the 21st century share the same goals that teachers had in previous centuries, even those in the Pythagoras Academy. We (I am a teacher, too) all want students to learn, evolve, and attain and practice competences. I have not studied Pedagogy myself, so I am not the person to consult, and this is not the book to read, if you want to learn about Pedagogy. I am a PhD in Computer Engineering for Education, and this is the focus of my research and my passion. However, although all my education is in Computer Science, I realized from the very beginning that without Pedagogy, computers cannot be used for education.

In general, whenever a Computer Engineer applies the computer to an area of interest, s/he must learn about that area, and in my case, this area has been Education. So, please let me help you with the topic that I have been studying for more than ten years now. Let me tell you that they have been ten wonderful years, in which I have seen how educational portals (you will learn what they are in Chapter 2) have evolved to become MOOCs (more about that in Chapter 2, too), complex and very sophisticated desktop authoring tools used to create educational computer exercises have evolved to friendly, easy-to-use on-line interactive computer educational programs (more about that in Chapters 3 and 4). Also, I’ve seen how the usability and interaction of educational programs have reached an edge with natural language dialogue –as provided by Pedagogical Conversational Agents (more about that in Chapter 5), and the most amazing change, the evolution of computers to the point where they can be integrated into mobile devices such as smart-phones, tablets, and also digital whiteboards and multi-touch tables (we will learn more about these in Chapter 6).

As you can see, there is still much to read, and please do not only read, but practice with the step-by-step solved exercises, and try everything indicated. Remember the Chinese proverb, and another one of my favorite quotes, this time by Benjamin Franklin: “Tell me and I forget, teach me and I may remember, involve me and I learn.” So, please get involved!

In the next Section, I will provide you with an overview of Bloom’s taxonomy (Bloom, 1975). Yes, I know, I told you this is a book written by a Computer Engineer, but remember, this is a book of how technology can be used for education in the 21st century, so it should start right, with pedagogical goals, and Bloom’s taxonomy can help you to categorize educational goals, so please keep reading.

### 1.2 Overview of Bloom’s Taxonomy

In 1956, Benjamin Bloom developed his taxonomy of pedagogical goals. It involved three domains: cognitive, affective and psychomotor. In this book, the focus is on the cognitive domain, which has a hierarchical nature: it is assumed that learning of higher levels depends on the learning of knowledge and skills in the lower levels.
So, although the taxonomy has later been revised and expanded (Anderson, Krathwohl, & Bloom, 2005), the core idea remains the same:

We must remember a concept before we can understand it.
We must understand a concept before we can apply it.
We must be able to apply a concept before we analyze it.
We must have analyzed a concept before we can evaluate it.
We must have remembered, understood, applied, analyzed, and evaluated a concept before we can create.

These sentences can be visually represented as a pyramid of levels as shown in Figure 1.2. I like the pyramid representation, as do many other teachers and researchers, because it shows the hierarchical nature of Bloom’s taxonomy, and it can serve as a guide for teachers to choose the level in which they are working in their class (although sometimes in a class several levels can be combined). Usually, however, beginners start with basic knowledge and comprehension (levels 1 and 2 – to remember and understand). As they understand the knowledge, they can apply and analyze that knowledge (levels 3 and 4 – to apply and analyze). Finally, students become experts in that knowledge (synthesis and evaluation), being able to evaluate and create new knowledge (levels 5 and 6 – to evaluate and create).

Figure 1.2: The six levels of the Bloom’s taxonomy
The teacher, according to the level of the students in the particular area of knowledge under study, must select a pedagogical goal. Any pedagogical initiative must have a goal in order to provide a clear idea of what is to be achieved, and so that your students know what it is expected of them. So, before choosing the technology, before organizing the material, before anything else, make sure that you have a goal for your class!

Figure 1.3 is a wheel provided by “More than English” (2013) with some goal verbs classified in the levels of the taxonomy. There are many classifications on-line that you can find useful. For example, the summary published by the Counseling Services of the University of Victoria\(^2\) adapted from Allyn and Bacon (1994), or the Bloom’s taxonomy action verb sheet published by Clemson\(^3\) (2013).

\(\text{Figure 1.3: A wheel of verbs of the Bloom’s taxonomy (source: More than English, 2013)}\)

\(^2\) See http://www.coun.uvic.ca/learning/exams/blooms-taxonomy.html (last visit June 30th, 2013)
\(^3\) http://www.clemson.edu/assessment/assessmentpractices/referencematerials/documents/Blooms%20Taxonomy%20Action%20Verbs.pdf (last visit June 30th, 2013)
However, with just a verb you cannot create the pedagogical goal. In general, to formulate a pedagogical goal you must use the following elements (at least 1 and 2, while 3 is optional):

1. An action verb in the infinitive (e.g. to remember, to apply, to translate...verbs in Figure 1.3)
2. Content (data, concepts/procedures/processes/attitude...)
3. (if necessary) Circumstances (level of domain/media used/scope)

A well formulated pedagogical goal could be: “To analyze the quality procedures used to evaluate higher education”. Finally, irrespective of the level of Bloom’s taxonomy, teachers must take into account the particular features of their class: the type of students, their number, the area of knowledge, resources and time so that the goals are realistic and achievable by the students.

For instance, if I am an English teacher of 20 students who have never studied English before, and they are really motivated, my first pedagogical goal for the class would be that they learn the numbers 1-10 (one, two, three and so on) in the first lessons. So, according to the rule previously given to formulate pedagogical goals:

1. I would choose a verb from level 1 of Bloom’s taxonomy: remember. For instance, “name” (see Figure 1.3, it just appears the first in the remember category)
2. I would add the content: “the numbers from one to ten in English”
3. No circumstances needed here.

The goal that I will tell my students would be: “Today, our goal is to name the numbers from one to ten in English”. Once I know that, my students know that, and we can start using technology to help us to achieve our goal. For example, I could use a computer program that makes the number appear together with the name, requiring the student to repeat it, or I could create a song containing the numbers from one to ten.

It would have not been realistic, if for the same class, my pedagogical goal was chosen from level 6. Imagine that I entered the same class of English learners without previous knowledge of the language and I formulate the goal: “Today, our goal is to create an English poem”. Surely, the result would be a disaster as students would not have either the vocabulary or the grammar to succeed in the task.

In the following subsections, we will focus on each level of the taxonomy in more detail. It is important that you understand these levels, and are able to formulate goals in each level, so that you can make use of the technology in this book to help your students achieve these pedagogical goals.
1.2.1 To Remember and Understand New Knowledge

The first level of the taxonomy corresponds to the goal of remembering. The definition of Bloom for this level is to remember previously learned information, such as data (e.g. names, dates, numbers, facts,...) or concepts (principles, methods, theorems,...). Some action verbs for this level would be arrange, define, describe, duplicate, identify, label, list, match, memorize, name, order, outline, recognize, relate, recall, repeat, reproduce, select or state.

The “knowledge” level is appropriate for beginners who are learning the basics of some new knowledge. For instance, this level would be appropriate for little children that are learning the letters of the alphabet. A pedagogical goal for them would be: “To memorize the letters of the alphabet”. They need to know the letters so that they can advance to higher levels of knowledge.

It could also be appropriate when reading a text, to find out what the students remember. In this case, a possible pedagogical goal would be: “To name the main characters of the story”. It could be a useful activity both for students of a foreign language and for those practicing reading skills.

The second level of the taxonomy corresponds to the goal of understanding. The definition of Bloom for this level is to demonstrate an understanding of the facts. It could be a sequence in a procedure, or processes. Some action verbs for this level would be classify, convert, defend, describe, discuss, distinguish, estimate, explain, express, extend, generalize, give examples, identify, indicate, locate, paraphrase, predict, recognize, rewrite, review, select, summarize or translate.

The “comprehension” level is appropriate for students who have learnt something, and now they have to prove they have understood it. For instance, this level would be appropriate for children that have learnt how to add numbers. A pedagogical goal for them would be: “To give an example of adding two numbers”. They need to understand the procedure of adding before doing something more complex such as a product. It could also be appropriate when reading a text, to find out what the students have understood. In this case, a possible pedagogical goal would be: “To summarize the story in your own words in three lines”.

1.2.2 To Apply and Analyze Knowledge and Competences

The third level of the taxonomy corresponds to the goal of applying. The definition of Bloom for this level is to apply knowledge to actual situations. Some action verbs for this level would be apply, change, choose, compute, demonstrate, discover, dramatize, employ, illustrate, interpret, manipulate, modify, operate, practice, predict, prepare, produce, relate, schedule, show, sketch, solve, use or write.

The “application” level is appropriate for students who already understand some knowledge, and they have to start applying it. For instance, this level would
be appropriate for children that have already learnt and understood how to add and know they need to solve a math problem in which it is necessary to add. A pedagogical goal for them would be: “To solve this Math problem by using one addition”. This is a task much more complex, than just knowing the numbers, understanding how to add, but now they need to apply the addition to solve the math problem.

It could also be appropriate after reading a text to write a different ending applying the knowledge of the story and some writing skills. In this case, a possible pedagogical goal would be: “To write a different ending in which the main character of the story changes his behavior so that he is now less shy”. It could be a useful activity both for students of a foreign language or for those wishing to practice reading and writing skills.

The fourth level of the taxonomy corresponds to the goal of analyzing. The definition of Bloom for this level is to break down objects or ideas into simpler parts and find evidence to support generalizations. Some action verbs for this level would be analyze, appraise, breakdown, calculate, categorize, compare, contrast, criticize, diagram, differentiate, discriminate, distinguish, examine, experiment, identify, illustrate, infer, model, outline, point out, question, relate, select, separate, subdivide or test.

The “analysis” level is appropriate for students who already understand some knowledge, they know how to apply it and now they need to analyze it to be able to do generalizations. For instance, this level would be appropriate for students that have already learnt and understood how to add, and they know how to solve math problems by using simple techniques on more complex problems in which not only one technique is enough but several techniques must be combined to solve the problem. A pedagogical goal for them would be: “To solve this Math problem explaining the techniques used and how they have been applied together”. This is a task much more complex, than just knowing the numbers, understanding how to add, or to apply one technique to solve a math problem.

It could also be appropriate after reading a text to write a review of the story, or for medical students when they have to analyze the data provided by a patient to diagnose the patient’s illness. In this case, a possible pedagogical goal would be: “To diagnose the illness of the patient according to the data provided”.

1.2.3 To Evaluate and Create

The fifth level of the taxonomy corresponds to the goal of evaluating. The definition of Bloom for this level is to compile component ideas into a new whole or propose alternative solutions. Some action verbs for this level would be arrange (depending on how you use the verb it can belong to different levels), assemble, categorize, collect, combine, comply, compose, construct, create, design, develop, devise, explain,
formulate, generate, plan, prepare, rearrange, reconstruct, relate, reorganize, revise, rewrite, set up, summarize, synthesize, tell or write.

This level is appropriate for students who already understand some knowledge, they know how to apply it, how to do an analysis and, now they need to evaluate the knowledge and think of other possibilities. For instance, this level would be appropriate for students that have already learnt and understood how to add, they know how to solve math problems by using simple and complex techniques, and now they need to evaluate whether each combination of techniques is optimum for each case. A pedagogical goal for them would be: “To devise the optimum combination of techniques to solve each problem on the list provided”. This is task much more complex, than just knowing the numbers, understanding how to add, or applying one or more techniques to solve a math problem. It could also be appropriate for finding a better solution to a problem. In this case, a possible pedagogical goal would be: “To find a better solution to the problem than the one provided”.

The sixth level of the taxonomy corresponds to the goal of creating. The definition of Bloom for this level is to make and defend judgments based on internal evidence or external criteria. Some action verbs for this level would be appraise, argue, assess, attach, choose, compare, conclude, contrast, defend, describe, discriminate, estimate, evaluate, explain, judge, justify, interpret, relate, predict, rate, select, summarize, support or value.

This level is appropriate for students who already understand some knowledge, they know how to apply it, how to do an analysis, how to evaluate it, and now they need to create their own knowledge. For instance, this level would be appropriate for students that have already learnt and understood how to add, they know how to solve math problems by using simple and complex techniques, they are able to find the optimum combination of techniques to solve problems, and now they are faced with the task of proposing a new technique to solve problems. A pedagogical goal for them would be: “To propose a new technique to solve the problem given”. This task is much more complex, than just knowing the numbers, understanding how to add, applying one or more techniques to solve a math problem or finding the optimum combination of already existing techniques because it requires creating something new (it could be a modification of previous techniques combined together). Such a goal would be appropriate for a PhD student.

1.3 How to Use This Book

So, great technology has evolved a lot in the last centuries, and there is a taxonomy with pedagogical goals classified in several categories, but how can I use this book? The answer is simple; this is a practical textbook, so I would not advise you just to read this book as a novel. On the other hand, this book pretends to be interactive. But, how can a book be interactive? The idea is that you practice the solved
exercises in each chapter, and solve the exercises that there will always be at the end of the chapter (the last Section). All the exercises are solved at the end, but please do not cheat, and try always to solve the exercises first on your own!

There is also a forum on the book’s website in which you can share your ideas and experience when doing the activities with other colleagues around the world. Remember the Chinese proverb, and as I said do not only read, or do the activities, get involved!

1.4 Exercises

Let’s start with a few exercises to get warmed up. Remember that all exercises are solved at the end of the chapter, but do not read the solutions until you have tried to solve the exercises on your own first! It is also possible that you may find alternative answers to these questions; in which case, you can share these on the book’s website.

1. Watch the video http://www.youtube.com/watch?v=mzil2Rlt8_nk, and write the top ten reasons for using technology in education according to that video. You can also share your opinion with other readers of the book on the website!

2. You have seen the opinion of institutions, but what about students? Let’s watch the video of an adult student. In particular, http://www.youtube.com/watch?v=rvyP-cwpHN8 is the final video project, a call to action, of a Master’s degree student in Education Media and Design Technology. Think about reasons why you could follow the call to action, and start using technology for education, and congratulations because if you are reading this book, you are about to put those reasons into practise!

3. Finally, what about little children? And teachers? Find at least one video with the opinion of a child, and another video with the opinion of a teacher about this topic. You can also ask colleagues, and see what they think, taking account of different factors: age, socio-cultural background, education, etc.

4. According to Bloom’s Taxonomy, categorize these verbs as educational goals in one of the six levels of the taxonomy:
   a. Understand
   b. Translate
   c. Compose
   d. Cite
   e. Estimate

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4 I have checked the links for these exercises on June 30th, 2013. If the link no longer works, please let us know at the book’s website, so that we can update it or add a similar working link. Even better, why not suggest another link?
5. Formulate a pedagogical goal for each one of Bloom’s taxonomy levels for the area of knowledge in which you teach (or would like to teach).

1.5 Solved Exercises

1) The top ten reasons for using technology in education according to the video are the following:
   - Students love it.
   - It engages key components of learning.
   - Professional development.
   - Makes life easier for teachers.
   - Improves test scores.
   - Help students with low attention spans.
   - Learn from the experts.
   - Encourages completion of homework.
   - Saves money.
   - Remove obstacles.

2) My personal reasons (this is a subjective question that you may answer completely different and there is no right or wrong answer) for using technology for education are to provide my students with more opportunities and experiences. I strongly believe that there are many possibilities for creating educational computer programs that students could use before going to class, during the class or to study after class, communication programs that foster collaboration among students, and mobile devices that allow students to work from any place connected to the Internet.

   Some years ago, a pedagogue told me something that I would never forget (it should be well understood by a pedagogue, but for a computer engineer it is very informative): “Try with your students several approaches, do not repeat always the same, reinvent yourself and you will always enjoy teaching”. Since then, I do not only talk during my lessons, or try to explain a concept in different ways, but instead use multiple instructional methods, combining these in order to experiment with methodologies and technologies so that I can find which ones provide the best results for the students and for me!
3) I chose YouTube to look for videos, I really like that website. Although as you may know, there are many more free Internet channels for education on the web. For example, Academic Earth, Big Think, Brightstorm, CosmoLearning, Futures Channel, Howcast, Internet Archive, Khan Academy, Learner.org, ResearchChannel, SchoolTube, Videojug, WatchKnowLearn, WonderHowTo, YouTube EDU or Vimeo. In particular, my choice for the opinion of a child was the video:

http://www.youtube.com/watch?v=0VSymMbMYHA

It was nominated as Best Educational Use of Video/Visual 2010 in the edublog awards, and it is very graphic when describing the problem of new generations that do not connect with teachers who do not understand that new generations live in a different era with new resources and new possibilities, and that they need their teachers to be aware of those advances too.

Regarding the opinion of teachers, I have chosen the video:

http://www.youtube.com/watch?v=WWcp8smECj8

What are your choices? Please, share them on the book’s website!

4) Understand, 2; Translate, 3; Compose, 5; Cite, 1; Estimate, 6; Know, 1; Apply, 3; Synthesize, 5.

5) I teach “Computer Science for Education”, so a sample pedagogical goal for each one of Bloom’s taxonomy levels would be the following:

- Level 1 (remember): “To define what an educational computer program is”.
- Level 2 (understand): “To classify the possibilities that computers can bring to Primary Education”
- Level 3 (apply): “To relate computer software for education to the Bloom’s taxonomy level that they can cover”.
- Level 4 (analyze): “To differentiate between the cases where it is useful to integrate an educational computer program before, during or after the class”.
- Level 5 (evaluate): “To collect evidence of advantages and disadvantages of using computers for education”.
- Level 6 (create): “To create your own educational theory about how computers can be used for education according to several students’ factors such as gender, age or socio-cultural background”.

Remember, these are just my samples, so please share your answers with other students on the book’s website, or if you are working in class with this textbook with other students in the class!

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5 You can find the links for these websites in the reference section of this chapter.
1.6 References

(last visit to all links on June 30th, 2013)

Academic Earth, on-line at academicearth.org
Big Think, bigthink.com
Bloom, B. S. (1975), Taxonomía de los objetivos de la educación, Marfil, Alcoy.
Brightstorm, brightstorm.com
CosmoLearning, cosmolearning.com
Futures Channel, thefutureschannel.com
Howcast, www.howcast.com
Internet Archive, archive.org
Khan Academy khanacademy.org
Learner.org, learner.org
ResearchChannel, youtube.com/user/ResearchChannel
SchoolTube, www.schooltube.com
Videojug, www.videojug.com
Vimeo www.vimeo.com
WatchKnowLearn, www.watchknowlearn.org
WonderHowTo, www.wonderhowto.com
YouTube EDU www.youtube.com/edu

Other interesting links to keep reading (there are many more!)

http://www1.prometheanplanet.com/es/
http://www.pearsonfronter.com/
www.multiclass.es
biblioteca.sfpaula.com
www.geniusnet.com
www.avtic.es
www.redalumnos.com
www.twiducate.com
misait.com/es
www.edmodo.com/es
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