Ideals and modern tools to achieve sustainability in higher education

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Keywords: education, sustainability, virtue, wrong/right boundaries

Abstract. *Higher education is responsible for all improvements which are expected to take place on all education levels and this work tackles two important issues the one being the definition of education and its ideals and the other one is the use of modern technology tools to promote such ideals and achieve sustainability. To define education two related philosophical structures are analyzed the one being Plato's definition of education and the other being Aristotle's midway of virtue. These two structures provide definitions and ideals to be used as foundations to build sustainability in higher education. Modern technology from there on could be used to help higher education in educating people who will be based on strong ideals, will develop adequate scientific depth and they will try being smarter than the machines. This can be achieved by using together modern technology and science so that the one supports and advances the other with critical role to be played by the ability of the educator to develop elementary educational software modules.*

Introduction

Education is meaningful if and only if is capable to make a clear distinction between wrong and right so that to help people acquire and use knowledge correctly and not in the wrong way. This part of education which is the foundation part needs support and development based on ideals and it is discussed in the first part of this work.

Sustainability is a popular term in modern times which is approached in many ways but most important it requires a well balanced person with education to be able to conceive a well balanced sustainable plan and furthermore to be able to make the effort to support the materialization of such a plan. The second part of his work provides a balanced model for teaching higher education courses having equilibrium between the unlimited depth of scientific knowledge and the analysis / synthesis and applications of structures for sustainable development maintaining always motives and challenges for the student and the instructor particularly by using high technology.

Education ideals

Ideals are provided by two philosophical structures which are chosen as foundation for education and may be considered to have similar or higher value for human sciences as Newton's Law in physics. Both of these

structures have diachronic validity and global acceptance and will be analyzed using mathematics.

Plato in his book "The Republic" defines education as: "*the therapy of the spirit …and as, when the body is sick, it needs medical treatment, when the spirit is sick, it needs education*". Consequently, Human spirit structure is defined by Plato as: *"…human spirit consists of three components or three states that analytically are: logic, desire, and anger".* Plato completes the definition of *education* by defining *healthy spirit* as follows: "… *logic keeps control over and balance between desire and anger*". To clarify the meanings of control and balance, Plato gives the following example: Compares spirit with a car pulled up by two horses - a blind horse representing desire and a crazy horse representing anger - and the coachman - being the logic - who keeps control over and maintains a balance between these two horses in order to move the car to the correct way (which is the way of virtue, Hatzopoulos J. N., 2004).

This example about healthy human spirit as a mathematical structure (see Figure 1) can be expressed by a rectangular triangle where the hypotenuse is logic and the two other sides represent desire and anger. A mathematical relation of healthy spirit can be established by Pythagoras theorem. This structure of human spirit resembles also a three

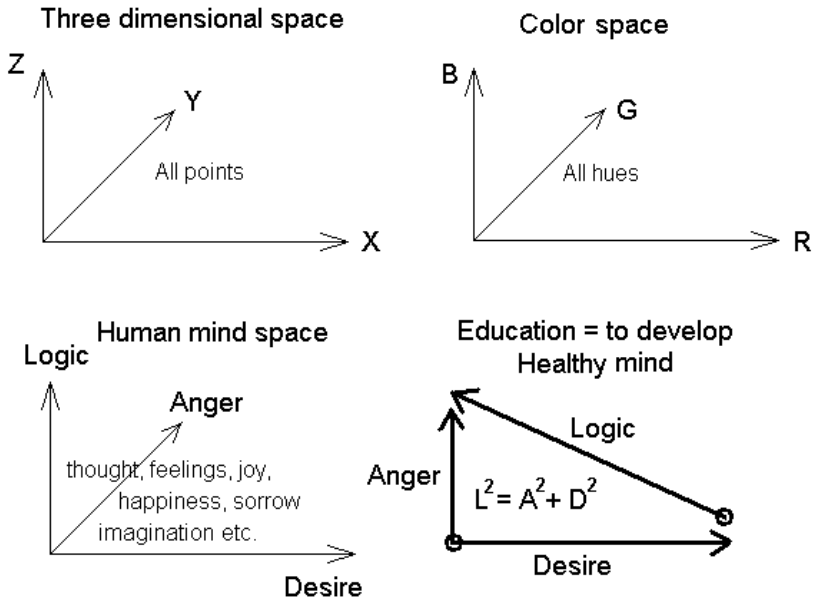

Figure 1. A mathematical analysis of the structure of education as an effort to balance the states (components) of human mind.

dimensional coordinate system where the three coordinates (X, Y, Z) can express the position of all points in the three dimensional space. Similarly three components (R, G, B) of primary colors are needed to express all color hues. As shown in Figure 1, the same thing could happen with Plato's three components of human spirit where all states of human mind (feelings, joy, happiness, sorrow, imagination, etc.) can be expressed by these three components.

It is important to notice that modern definition of education which is related to the production and transfer of knowledge without any

philosophical foundation creates a controversy and does not help a person to focus and direct most actions in the correct (sustainable development) direction.

Virtue ideally represents correct human action and as a structure is defined and analyzed in all its extent and in all its depth by Aristotle in his work *The Nikomachean Ethics*. According to Aristotle, Virtue is: *mesotita* (a midway) and is to be found in midway, in between two extreme actions or "badness". Aristotle then gives the following example in order to clarify the structure of virtue: If bravery is a virtue then the brave person is to be found in midway, between the provocative and the coward person, …*and when one is brave, then the coward will call him provocative because he is beyond coward's capacity, while the provocative will call him coward because he is beneath provocative's capacity*… Accordingly, one could characterize thrifty as a virtue that is to be found in midway between stinginess and overspending and the stingy will call the thrift as overspender while the overspender will call the thrift as stingy.

Aristotle also defines the person of virtue *as the one who is trying to be a person of virtue* which means that virtue is the effort to maintain actions within the midway and which allows extreme actions under certain conditions as is for example, self defence. The important idea about this structure is that it is completely fitted within human dimensions.

Mathematical analysis – boundaries of wrong / right

Examining more carefully the example that Aristotle gives about the brave person, who is a person of virtue, then he/she will be considered by the coward as provocative, which means that the coward, believing that he/she is a person of virtue, underestimates virtue and therefore mathematically this can be considered as committing an error with a negative sign. On the contrary, the provocative considers the person of virtue as coward and accordingly overestimates virtue hence he/she mathematically can be considered as committing an error with positive sign. It is evident that humans, by their own nature make errors because human brain is anatomically based on neurons and such systems are not absolutely correct. For example, if one walks over a flat road and meet a small obstacle like a rock having the size of a football, then the way one rises the foot to pass over the obstacle is different each time one walks over. There is an optimum way to pass over the obstacle with minimum energy (zero error) which can be approximated with practice but it will never be followed exactly. There is a lower limit and an upper limit to rise the foot to pass the obstacle with optimum energy (correct, virtue) without having a false step. Finally there are many cases outside these limits where it takes place a false step (negative and positive error). How bad the false step is depends on the damage caused to this person (absolute value of error). It must be noted that, repeating an effort, neurons are trained and constantly improve their performance but they never become perfect. This example may help to define precisely the boundaries of wrong and right where wrong occurs by a false step and right occurs with the effort for optimum energy.

Having this analysis in mind, then human error structure can be expressed mathematically as follows (Hatzopoulos, 2004): We may establish an axis X (See Figure 2), consisting of three straight line segments:

(a) The segment on the left called "Error on the left (M_L)", measures the degree of error or badness of a human being and shows the amount of underestimation of virtue (negative error);

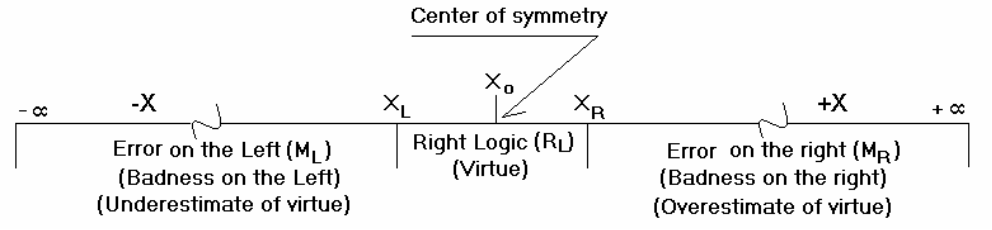

Figure 2. Structural elements ordered along X axis (Hatzopoulos, 2004).

(b) The intermediate segment in the middle called "Right Logic (R_L)" or virtue (correct).
(c) The segment on the right called "Error on the Right (M_R)", measures the degree of error or badness of a human being and shows the amount of overestimation of virtue (positive error).
(d) The location X_o with zero error we call *Supreme Being* location because no human being is considered as having zero error.

As shown in Figure 2, this distribution of human error is symmetric with respect to the central point X_o of zero error in the intermediate segment of virtue. However, human error is expanded from point X_L to minus infinity and from point X_R to plus infinity. If humans would be able to estimate precisely their error they would choose a specific location along the X-axis. Notice that many times people estimate such a location as are the political parties, community clubs and their followers. It must also be noted that the estimation of location of boundaries of midway of virtue has to be subjective in order to stay within human dimensions and therefore requires a wider consensus (stochastic model) because each individual may have a different opinion on the subject and such a consensus may be valid only if there is a minimum bias in expressing such opinion. Minimum bias may be considered if the voters have an education whose effort is to develop a healthy mind as defined by Plato. Such matters about the influence of bias are discussed in detail by (Hatzopoulos, 2004). Consensus means democratic procedures and voting which are philosophically founded as an effort to define the mid way of virtue.

It is important to understand that since any human action includes an error (X) it means that this action to a certain degree is correct (Y) so that wrong (X) and right (Y) coexist within such action. If wrong and right are to be quantized and related to each other, then they must be inverse proportional quantities. A simple function to express this is as follows:

$$\mathbf{Y = 1/X} \qquad (1)$$

Where (X) is the wrong or error and (Y) is the correct or right.
From Equation (1) it is evident that:

$$\text{for } |\mathbf{X}| \rightarrow \mathbf{0} \quad \text{then} \quad \mathbf{Y} \rightarrow \mathbf{infinity.} \qquad (2)$$

Since X_L, X_R are located on the common boundary between wrong and right, then both variables X and Y must have exactly the same value (Hatzopoulos, 2006, pp. 328) on this common boundary. However, we look for a value in X-axis where:

For boundary X_R : $\mathbf{X = Y}$ and for boundary X_L: $\mathbf{-X = -Y}$ (3)

Applying the boundary condition (3) on Equation (1) we have:

$$\mathbf{X = 1/X} \text{ or, } \mathbf{X^2 = 1} \text{ or, } \mathbf{X = \pm 1} \qquad (4)$$

This determines precisely the borders of midway of virtue (Hatzopoulos, 2004) as having values:

$$\mathbf{X_L = -1,} \text{ and } \mathbf{X_R = +1} \qquad (5)$$

Considering that such borders are defined by voting and the probability density function of human error is f(x) then as a stochastic model may be chosen the *Gaussian standard normal distribution* ($\mu = 0$, $\sigma = \pm 1$ Hatzopoulos, 2004).

The Aristotelian midway of virtue has a universal validity, for example, taking into consideration the orbit of the earth around the sun, one may observe that the earth will never follow exactly the same path and there is a midway where orbits of the earth must occur in order to have equilibrium. If the earth gets off such bounds towards the inside, then the earth may collide with the sun, if the earth gets off such bounds towards the outside, then the earth may get lost in space. This example defines also precisely the boundaries of wrong and right where wrong occurs when the earth tends to collide with the sun (negative error) or tends to get lost in space (positive error) while right occurs within the midway of orbits which follows until now.

Supreme Being

As indicated by Relation (2), Supreme Being has a virtue with magnitude approaching at infinity and, consequently, it is not possible for this Being to have even a minimal badness at all times. Consequently, if we accept that Supreme Being has any of human weaknesses at any time, we immediately depart from the location X=0 and thus we have not just one but numerous such beings like human beings. Putting on the same diagram shown in Figure 3 both the error function X and the correct

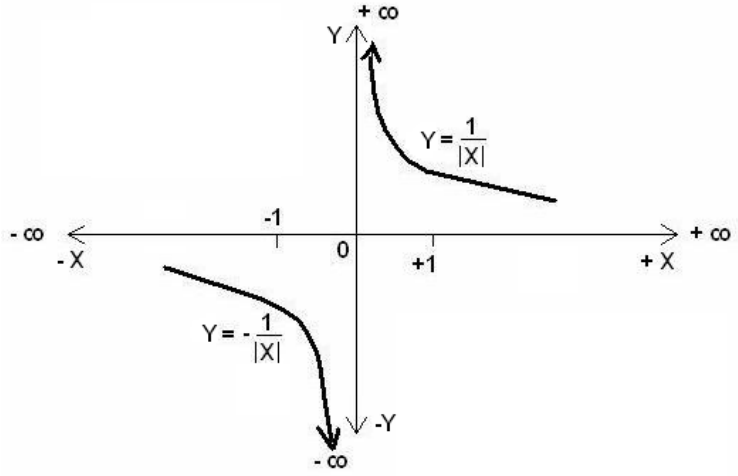

Figure 3. Virtue for the Supreme Being ranges from minus infinity to plus infinity.

(virtue) function Y = 1/X (Y - axis is perpendicular to X - axis) one may notice that if X takes values from -1 towards zero, then Y moves towards minus infinity. On the other hand, if X takes values from +1 towards zero, then Y moves towards plus infinity. This indicates that Supreme Being is found in one single location of the X axis and has a virtue which covers all values in universe from minus infinity to plus infinity. This is one and unique location because if departing even with a small amount from location zero, say 0 + e, or, 0 – e, where e is a very small number, then there are many beings in such location with human weaknesses and not a supreme being.

This analysis reveals the existence of an absolute harmony and perfection in universe which is something that some people are trying to locate without success and they get lost by searching because such perfection is beyond human dimensions. However, using mathematics one may observe that it is possible to locate harmony and perfection even in an ideal state.

Didactics

According to the previous analysis mathematics were used to describe philosophical structures of Plato and Aristotle about education. Therefore, mathematics is a valuable tool of human mind to perform analysis and synthesis of simple or complicated structures (James Franklin, 1995). Consequently, it must be realized that taking out mathematics from any course in higher education the scientific analysis to be performed could be incomplete. This is very important for those they want to improve didactics. Looking at student's status one may see that about a 20-30% are talented students in mathematics and they understand and learn theories right away and therefore for those students there is no problem. The majority of students 70-80% need more help to understand mathematics. A didactics method which could help such students is to use application examples from every day's life (Hoyles, C. and Noss, R. 2003) and such a method is known as the R.E. Gross problem solving method (Gross R. E., Zeleny L. D., 1958). A complete example of this method is given by Manolas E., 2006. R.E. Gross method if combined with computer programming to obtain quick results on complicated application problems could improve didactics and could also help students to advance (in being smarter than the machine) into the new technology era.

Working on students at University level one may be the recipient of all problems students have from elementary school to the high school and lykeio (senior high school) in mathematics. Trying to decode the problems students have in this area it is evident that wrong didactics is followed and perhaps the problem can be located at the following practice by most educators in mathematics:

1. They do not realize that mathematics is the science of structures (James Franklin, 1995) and as such is a tool of human mind.
2. Because of attitude #1, they do not orient their didactics towards applications to create motives to the students but instead they spend their time on theories which for the talented students there is no problem but for most of the students it does not make sense and they

miss the substance creating gaps which generate opposite feelings and hateness about mathematics.

3. Many mathematicians particularly the good ones do not have experience about applications of mathematics and they usually do not like applications.
4. Computer programming in a simple computer language, Visual basic for example, is not present in curricula of elementary and secondary education schools.

Pedagogy as a science must be able to adapt itself at least in cosmogonic changes when they take place. Since the decade of 1980 and afterwards a cosmogonic change took place which brought in the foreground an amazing human invention tool and this is the personal computer. The fact that this tool was evolved to a personal use from a team of young men that manufactured the Apple computer (Leigh Kimmel, 1998), shows how big can be an offer to humanity by an insignificant team of people when they know how to use their free mind. IBM Company which was a colossus in computers at that time was waiting to evaluate the development of Apple computer in order to make its own move. Despite the IBM PC movement and the Microsoft which developed the IBM PC operating system, the team of young men that made the Apple went ahead to accomplish the manufacture of Apple Macintosh whose characteristics Microsoft managed to reach ten years later and never up today was able to exceed it.

The right use of information technology presupposes good knowledge of computer and its capacities and over all the ability to develop software. The correct pedagogic process could adopt as an objective that *whoever is educated to use the computer as a tool is always more intelligent than the computer*. This objective could drop the myth about computers and help students with the power of knowledge to use the computer as an effective tool in all scientific fields and in all kinds of activities. The largest advantage of computer as a pedagogic tool is that in any subject or problem or work can give fast results and in this way creates motives in students to study with higher attention the scientific bases. If students have the ability to develop software, then they can study each piece of scientific work or research by testing it in the computer and in this way they obtain an essential confidence that they know this scientific part of the study or research. Young people must understand the example of the team which developed the Apple computer and they must realize that any moment they decide to move ahead, they can also take initiatives using their free mind putting objectives and standards thus helping themselves and the society.

If those issues are taken seriously into consideration then it is anticipated to have improvement to the current situation. An ideal improvement could be to obtain a percentage of 60-70% of students to understand and learn mathematics and science. It must be noted that probability between $\sigma = -1$ and $\sigma = +1$ in standard normal distribution is within this percentage range.

A complete education model

The ideals of education as developed provide the necessary foundation to build sustainability. However, sustainability starts from the inside of a

person and has to do with the internal balance which is maintained by the effort to develop a healthy mind and the effort to follow the midway of virtue. This effort helps the person to clearly identify the boundaries of wrong and right and focus most of mind energy to perform correct actions (sustainability is assumed as a correct action). It must be noted that if boundaries of wrong and right are not clearly defined then there is a danger that half of mind energy may go to the wrong way and the other half may go to the correct way with null or negative results. One such example is if a group of people are educated to exterminate another group of people and reversely.

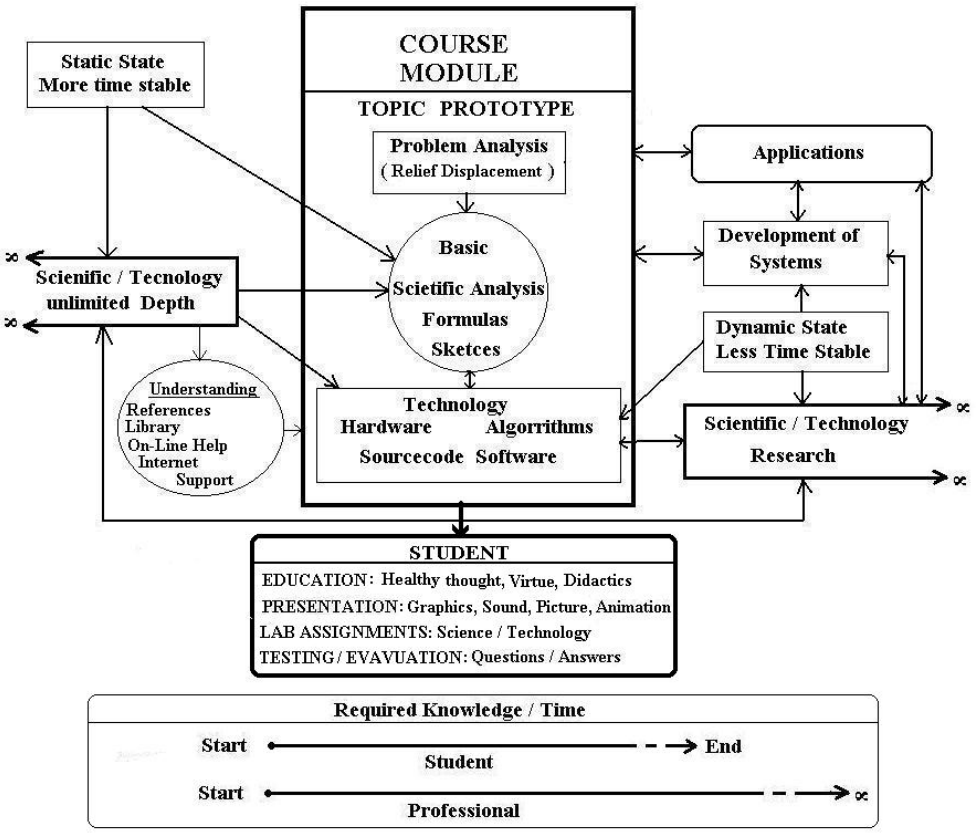

Figure 4. The course model.

The next step is to build on these foundations a higher education by creating a balance between the unlimited depth of scientific knowledge, and the applications. Notice that applications together with technological developments (on sustainable development) are supported by these scientific bases. Also scientific bases are supported by mathematics and therefore didactic issues discussed about mathematics must be taken into consideration. At the same time there must be given motives to the students to follow the rapid developments in science and technology and help them to build an internal confidence that they are smarter than the machine. To achieve these goals educational material such as a course model is proposed in an effort to put some elementary standards and also to integrate science and technology together with education into a balanced configuration shown in Figure 4. However, the key in student education

are the lab assignments which are designed to cover application examples and to use modern technology (computer programming) to understand science. Science itself, as discussed in didactics, may be boring, technology therefore is able through educational software to provide quick answers to complicated scientific problems and this creates motives for the student to study the scientific aspects of the problem (Hatzopoulos, 2005).
In Figure 4 there is the course module at the center, the scientific knowledge of unlimited depth on the left and the applications on the right. All of these are interconnected in a balanced way to provide education to the student and training to the professional. The course is subdivided into topics and each topic is covered in a class session.

Each topic has a prototype composed of the part of problem analysis; the part of basic scientific analysis; and the technology part (see Figure 4). The part of basic scientific analysis, which is a more time stable part, is connected through links to an almost unlimited number of scientific sources and the student has the choice to select and study at the necessary depth. The technology part uses the scientific bases to develop appropriate educational software, which illustrates how existing systems work, and it proves that the scientific bases are correct. This part is more dynamic and less time stable. The technology part is very important particularly for next generations because there is a tendency for younger people to treat existing systems as black boxes. They do not have enough help if asking questions related to the software, and because they are generally discouraged to get involved with the inside structure of such systems they loose interest on the scientific part the system is based on. The technology part is connected through links to an almost unlimited number of research depth, and software development sources and students have the choice to select, study and practice at the necessary level.

The course module is connected to existing systems and some of them may require an appropriate license to run by the student. Important links to the course module are potential applications. A variety of application projects will enhance the usefulness of the topic in a divergent manner. The more application projects exist, the more people from specialized applications will attend the course, and the more technology and data will be useful.

In Figure 4 is also shown the time a student needs to finish the course while time for a professional is open ended.

This course model as discussed above, gives emphasis to the educational software. This software must be composed of simple modules applied directly to the scientific aspects of the course topics. The software development process has been advanced over the last decade and continues its advancing course with increased speed. This helps the developer by providing an almost unlimited number of tools, although some times it creates confusion because of the proliferation of such tools and facilities. The *object oriented open source software development* at present is the dominant approach to modern application problems and helps to develop a project with reusable code thus minimizing the source code development. The software development for educational purposes in a course topic, as stated earlier, is important to test the scientific procedures and make sure they work thus creating motives to study science at a greater depth. Such

software can be based on any programming processor. It must be clear that the purpose of such a course is not to train students on software development but to help them understand the scientific bases of the course topic and the way existing systems function and work from the inside. An advanced course, however, oriented towards the applications must use professionally developed software. A complete example based on this analysis is given by (Hatzopoulos, 2005).

Conclusions

This work through practical examples explaining the structure of human mind and searching for ideals within human dimensions (Plato: The Republic, Aristotle: The Nikomachean Ethics) managed to provide a clear definition of education and to precisely lay down the boundaries of wrong and right. A proposed definition of education could be: "*the effort to develop a healthy mind to those who try to follow the midway of virtue*". A proposed model for the boundaries of wrong and right could be for human error the *Gaussian standard normal distribution* ($\mu = 0$, $\sigma = \pm 1$) with the right (midway of virtue) being within the error boundaries from minus one to plus one and the wrong (badness) being outside these error boundaries. This effort using mathematics to locate such boundaries helped to found philosophically the democratic procedures as the ones used to define the midway of virtue and also through the *Supreme Being* definition to locate the absolute truth and absolute harmony in Universe. Such proposed ideals are within human dimensions and could have a diachronic value and a global acceptance.

This work revealed the importance of mathematics in sustainable education proving that the analysis of a structure without the use of mathematics could be incomplete and in conclusion it is suggested that mathematics must be considered and used as: *a valuable tool of human mind to perform analysis and synthesis of simple or complicated structures*. Mathematics thus help to *define unknown elements of a structure based on their functional dependence on other known elements.* Didactics on mathematics (Hoyles, C. and Noss, R. 2003) must be given more emphasis targeting to a 70% student understanding of mathematics and taking into consideration that most good mathematicians do not like applications and therefore do not have same good performance as teachers.

Sustainability in higher education led to the development of a prototype for course modules based on elementary standards where modern technology is used to create motives to the students and study science at any desirable depth (Hatzopoulos, 2005). Didactics thus can be significantly improved using application case examples based on every day's practice (Hoyles, C. and Noss, R. 2003) and following an evolved E.R. Gross (Gross R.E. et al, 1958, Manolas E., 2006) problem solving model with the addition of computer programming. Ability for software development by instructors and students for educational purposes could significantly improve sustainability in higher education especially if relevant courses are introduced in primary and secondary schools.

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