

PEDAGOGY MODELING FOR SCIENCE BASED SUBJECTS

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ABSTRACT

This paper utilizes the Jacques Delors Pillars of Education as the basis of design, a pedagogy model appropriate for science based subjects and courses. Although Jacques Delors has investigated and explored the main areas of education, as a discipline however, education has gone through some fundamental changes since 1996. The current literature for teaching pedagogy does not cover any specific model that is solely designed for the unique requirements of teaching scientific subjects. The proposed pedagogy model in this paper considers all the relevant and important aspects of education, not only in today's current climate, but also in the foreseeable future. More importantly, as the educational system endures rigorous changes there are some fundamental matters that need to be carefully considered, including flexibility, industry linkss, multi-skilling and professional accreditation, which are all utterly crucial for science-based subjects and courses.

KEYWORDS: Educational Modeling, Jacques Delors Pillars of Education, Educational Systems, Educational Pedagogy, and Science based Subjects and Courses

1.0 INTRODUCTION

In confronting many challenges that the future may bring, human kind sees in education an indispensable asset in its attempt to attain the ideas of effective education. While education is an ongoing process of improving knowledge and skills, it is also primarily an exceptional means of bringing about personal development and building relationships among individuals and groups, such as scientific factions. Therefore, these scientific groups require unique educational systems and modeling.

The Four Pillars of Education (Jacques Delors Pillars of Education), described here are a fundamental aspect of any educational modeling, especially in the scientific arena. These four pillars of knowledge cannot be anchored solely in one phase in a person's life or in a single place. There is a need to re-think when education should be provided in people's lives, and the fields that such education should cover. The periods and fields should complement each other and be interrelated in such a way that every person can gain the most from their specific educational environment throughout their lives.

Although Jacques Delors has investigated and explored the main areas of education, since that time, some fundamental changes have occurred within the discipline (Hager at el. 2012). The proposed pillars of education consider all the relevant and important aspects of education, not only in today's current climate but also in the foreseeable future. More importantly, as the educational system goes through rigorous changes, there are some fundamental matters that need to be carefully considered. These issues include flexibility, industry links, multi-skilling, and professional accreditation. These will be discussed in detail later in the paper. Although Jacques Delors' Pillars of Education is quite aged, it does however provide a solid platform to create a pedagogy modeling for science-based subjects.

2.0 JACQUES DELORS PILLARS OF THE EDUCATION

In his report, Jacques Delors provides the following explanation with regards to education: “education must transmit efficiently and on a massive scale, and increasing amount of constantly evolving knowledge and know how adapted to a knowledge driven civilisation, because this forms the basis of the skill of the future. At the same time, it must find and mark the reference points that will make it possible, on one hand, for people not to be overwhelmed by the flows of the information, much of it ephemeral, that are invading the public and the private domain and, on the other hand, to keep the development of the individuals and the community as its end in view”.

Although this is a very sound explanation on education in general, a more specific definition of education also needs to be considered. Arriving at a specific definition of education would involve the understanding of other unique expectations and outcomes of education in different fields of study such as science based (Schiewer, 2013). An effective educational pedagogy for specific disciplines such as science requires careful implementation and establishment. As previously stated, the Four Pillars of Education described in Jacques Delors’ report, (Learning: the treasure within - 1996) is the core basis of this paper. Figure 1, provides the generic pillars of education adopted from Jacques Delors Pillars of Education

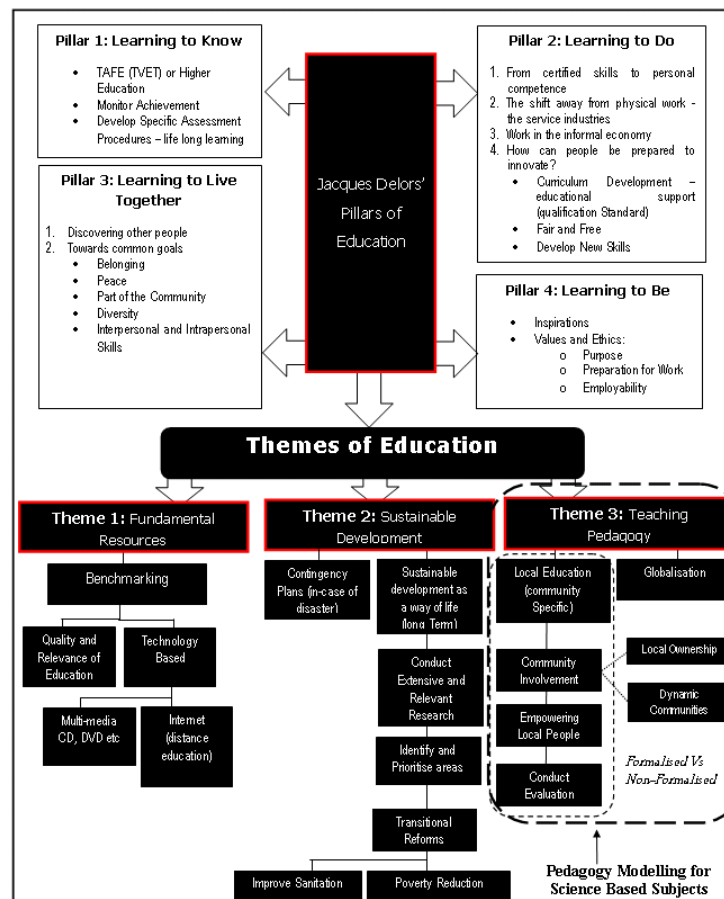


Figure 1: Pillars of Education (Adopted from Jacques Delors Pillars of Education)

As it is noticed, the proposed pedagogy modeling for science-based subjects is within Them 3: Teaching Pedagogy, which is mainly created in correlation with Jacques Delors’ Pillars of Education. Based on the Delors Pillars,

the “Themes of Education” (Sub-classification of the points already referred to by Delors report) is developed to categorize various aspects (of Delors’ Pillars of Education) into more relevant and specific sections. The following sections explain this process in detail. Although the Jacques Delors Pillars of Education are self explanatory, they do however require some basic clarifications.

The next section explains pillars of education in detail, and each Pillar has been included for better understanding of the mechanisms involved. Some of these pillars will be built into the proposed pedagogy modeling of science-based subjects. Delors’ Pillars include:-

2.1 Learning to Know

In relation to the Learning to Know pillar, Jacques Delors argues that *“as a means its served to enable each individual to understand at the very least enough about his or her environment to be able to leave in dignity, to develop occupational skills, and to communicate”*. This indicates the importance of education in retaining better skilled populations for the benefit of the community and indeed the nation. In an ever-changing employment environment, prospective individuals need to understand the actual requirements of their professions regardless of their field of science and ensure they are competent.

Jacques Delors also adds, *“as knowledge is manifold and constantly changing however, it is increasingly futile to try to know everything – after basic education, omnidisciplinarity is an elusion – but specialization, even for the future researchers must not exclude general knowledge”*. The concept of general knowledge or generic understanding is something that some well-developed countries take for granted. General education is an effective method of delivering basic knowledge and it is fundamental in developing capable individuals. As Jacques Delors notes, *“a general education brings a person into contact with other languages and areas of knowledge, and in the first instants makes communication possible”*.

Furthermore, Learning to know presupposes learning to learn, calling upon the power of concentration, memory and thought. The ability to learn is much more than the ability to concentrate. It requires the conception of being selective about what we learn by heart. As situations change so there is the need to embrace new ideas and concepts. Therefore, acquiring knowledge is a never-ending process and can be enriched by all forms of experience. Important elements of this Pillar include, TAFE (TVET) or Higher Education; Monitor Achievement; and Developing Specific Assessment Procedures, thus science-based specifics.

2.2 Learning to Do

In relation to the Learning to Do Pillar Jacques Delors states *“learning to know and learning to do are to a great extend in-dissociable, but learning to do is more closely linked to the question of vocational training”*. TVET (TAFE in Australia) provide effective vocational training, especially as science-based training is utilized across the world in one way or another. This type of educational training provides a more hands-on approach rather than more traditional theory-based methods as taught in universities. However, even universities have begun to understand the importance of employment readiness in their graduates; hence they offer various vocational based programs such as Industrial Based Learning (Hager at el. 2012). Being work-ready is significant for any economy, and thus the majority of employers prefer their graduate (new) employees to be work-ready, with less time and money required on further training of their new graduate workers. This is important in a competitive economy where the lack of resources is quite high.

In addition, Jacques Delors points out, *“The function of learning is not limited to work but must respond to the broader objective of formal or informal participation in development. It is often as much a matter of social as of occupational skills”*. Although the concepts of formal and in-formal education will be looked at later, it must be acknowledged that there is no one proper method of educational delivery system. For nations to be productive, they need to possess flexible educational approaches. This flexibility is important to cope effectively with uncertainty and to play a part in creating a future (nation building). Important element of this Pillar includes, curriculum development, which needs to consider qualification standards that are required by the external bodies such as the Australian Institution of Engineers.

2.3 Learning to Live Together and Learning to Be

In relation to the Learning to Live Together Pillar Jacques Delors asks a question; *“is it possible to devise a form of education which might make it possible to avoid conflicts or resolve them peacefully by developing respect for other people, their cultures and their spiritual values?”*. One way of avoiding conflict is by ensuring that we do not force and apply our own ideas and values upon others. Moreover, we need to carefully listen to local people, and understand and respect their way of life.

In relation to this Pillar, Jacques Delors adds *“more than ever educations essential role seems to be to give people the freedom of thought, judgment, feeling and imagination they need in order to develop their talents and remain as much as possible in control of their lives”*. Although this is correct, in some parts of the world, some communities or nations control and restrict their educational system. They do this by teaching their population their own ideologies and beliefs. This is particularly quite common in middle-eastern countries such as Afghanistan, and Pakistan. These countries also seem to believe that the western ideology is wrong, and therefore attempt to manifest their own philosophies.

Furthermore, Jacques Delors adds *“education is above all an inner journey whose stages correspond to those of the continuous maturing of the personality. Education as a means to the end of a successful working life is thus very individualized process and at the same times a process of a constructing social interaction”*. This statement reflects the changes in which education will bring in one’s life. In other words, as people become more educated, they seem to take more logical and calculated risks in their lives, thus, education in general provides an alternative way of thinking and living. Both Learning to Live Together and Learning to Be need to be considered as background elements, when the pedagogy modeling for science-based subjects is being constructed, which provides broader philosophy.

The next section describes the Themes of Education, which are mainly a more detailed analysis of points already referred to by Delors’ report. As previously discussed, the “Themes of Education” are a sub-classification of the points already referred to by Delors’ report. This sub-classification is developed to categorize various aspects (of Delors’ Pillars of Education) into more relevant and specific sections.

2.4 Themes of Education - Theme 1: Fundamental Resources

As with any new planning, having the right and sufficient resources are fundamental. Although Delors’ model briefly discusses such a need, this element needs careful consideration when pedagogy modeling of science-based subjects is being considered. Having the right resources does not simply mean having the sufficient budget. It also includes possessing the right tools, materials and expertise. These tools and materials are in particular necessary when any organization wants to develop new initiatives, procedures, or even equipments to measure their own performances

(Schiewer, 2013). For these tools to be effective, optimized processes such as benchmarking could be used. Benchmarking is a process in which organizations evaluate (measure) various aspects of their processes in relation to best practice, usually within their own sector, such as education.

In addition, diverse regulatory settings are required to establish effective educational standards, especially for science-based subjects. Effective evaluation and measurement is an important key to improving the educational system throughout the world. One important aspect of this evaluation is to ensure that the quality and relevance of education is current and correct. Another important aspect of the technology-based environment is distance education via the internet. As an alternative to provide education to remote societies where it is difficult for individuals to attend schools (due to distance or lack of available time), distance education provides a good alternative. However, there are some important issues when this option is considered, such as; availability of the technology to those remote communities, and lack of knowledge or ability to use such medians. This may require initial training of the individuals to use the technology effectively, and ensuring they have on-going assistance and support when required.

2.5 Themes of Education - Theme 2: Sustainable Development

In general, sustainable development represents a long-term and continuous development, such as sustainable science-based educational systems. In education, sustainable development creates skills, knowledge, and values that promote behavior in support of a sustainable environment. Sustainable educational development is not confined to formal schooling; it also occurs in a wide range of informal education settings.

It is important to note that the next Theme (Theme 3) is the most influential element in relation to pedagogy modeling for science-based subjects, which is the focus of this paper.

2.6 Themes of Education - Theme 3: Teaching Pedagogy

Queensland's Department of Education, Training and the Arts (DETA) defines pedagogy as: *“Pedagogy is the art of teaching. Effective pedagogy, incorporating an array of teaching strategies that support intellectual engagement, connectedness to the wider world, supportive classroom environments, and recognition of difference, should be implemented across all key learning and subject areas. Effective pedagogical practice promotes the wellbeing of students, teachers and the school community - it improves students' and teachers' confidence and contributes to their sense of purpose for being at school; it builds community confidence in the quality of learning and teaching in the school”*. In addition Barrett and Moore (2011) explain, *“Pedagogy goes forward when we find understanding that makes the knowledge stick”*. Furthermore, they argued that there are four multiple knowledge needs (Pedagogy Theories) within the learning environment; this is shown in figure 2.

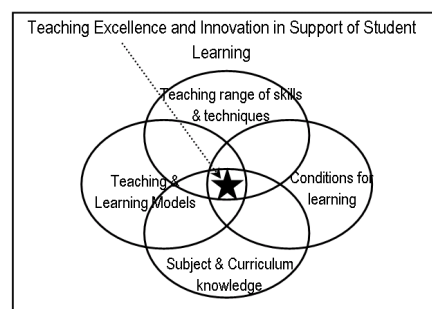


Figure 2: The Four Multiple Learning Needs (Barrett and Moore, 2011)

These four “multiple knowledge needs” within the learning context must be carefully addressed and therefore, be embodied into science-based teaching practices. As the demand in higher education is rapidly growing world-wide, universities and other educational institutes (such as TVETs and TAFEs) are also changing their teaching philosophies to respond to this challenge (Burke, 2012). Therefore, a successful science-based teaching pedagogy needs to be considered and incorporated in all of the four multiple knowledge needs.

In addition to these multiple knowledge needs, the teaching range of skills and techniques is another fundamental issue. Teachers are often mentors and critical guiders that are required to make assessments on learner behavior, and examining (on a student by student basis) what needs must be met in order for the learner to gain maximum benefit from subject content (Cullen, Harris, and Hill, 2012).

The following sections provide important elements of Teaching Pedagogy such as diversity, and globalization. These are an important aspect of science-based teaching pedagogy and educational modeling.

- **Diversity:** One important aspect of a good teaching pedagogy is the acceptance of diversity (Wallace, 2006). Being culturally diverse is very significant in any organization, in particular in educational institutes and universities (Davis, Devlin, and Tight, 2010). Commonly speaking, diversity in education encourages academics to be aware of how different students perceive the world and how an awareness of this can enhance efficiency of an organization. Creation of pedagogy modeling requires the knowledge of diversity and its significant influences on the student’s cohorts. To effectively create this model, special considerations are required to ensure that opportunities are provided for attitudes to change, however slowly, which remains imperative in all educational institutions.
- **Globalization:** It is important to note globalization’s exclusive relationship within the science-based teaching pedagogy. Although in general globalization has its own complexities, it provides a good opportunity to evolve universally. The fact is that globalization is becoming increasingly embraced and accepted generally in various professional fields; this includes science-based fields. The education sector itself is subject to globalization (Ennew, 2012). This has led to differing views about the role of the education sector in nation building. While many embrace this concept, there are other (more traditionalist critics) who reject the idea of educational globalization. These so-called traditionalists argue that globalization requires enormous effort and must be strictly controlled and monitored, or it will lack the intensity to be effective.
- **Formalized vs Non-formalized Education:** In assessing formalized versus non-formalized education, there needs to be careful consideration from individual and community perspectives. While formalized education involves the traditional method of training, non-formalized deals with “Local Education” (Stewart, 2012). The local education in this context represents the involvement of the community by empowering individuals within it. Thus, this involves getting people from various positions (within their communities and cultures) such as women, to be comprehensively involved (and at times take charge) in the planning and carrying out their educational designing and operations. However, careful evaluation must be carried out to ensure that firstly, there is a smooth transformation, and secondly, any adjustment can be made to improve the current educational system. Science-based subjects are traditionally formalized subjects, however as education in general is going through some fundamental changes (such as distance education), pedagogy modeling for science-based subjects needs to

carefully consider non-formalized education. This needs to include local education, such as education developed and designed for disadvantages at the community level.

3.0 CRITICAL ANALYSIS OF DELORS' PILLARS OF THE EDUCATION

This section analyses some critical aspects of Delors' Pillars of Education, which are required to create the pedagogy modeling of science-based subjects. As previously discussed, Delors' Pillars of Education cannot be anchored solely in one phase in a person's life or in a single place. Delors' Pillars complement each other and can be interrelated in such a way that all people can get the most out of their own specific educational environment throughout their lives. The following are some of the issues that the Delors report lacks in sufficiently detailing or requires further clarification, especially for science-based subjects:-

- As discussed, one of the shortcomings includes the lack of case-specific analysis. Garrison and Vaughan (2011) argued that "Universal education through schooling is not feasible". Currently, there is a significant push towards universal education, and this indicates how education philosophy has changed with the times (Sterling, 2010). Although the Delors report was current at the time, the current era requires a more up-to-date educational philosophy, hence why educational systems have gone through fundamental changes in recent years. Currently, there is significant emphasis on universal schooling to promote equal education for all. Case-specific education provides a more equal level of education for all, regardless of societal hierarchies. Unfortunately, currently the privileged populations or high-ranking individuals of each society seem to be getting better and more specific education than the rest of the population. Case-specific education reviews each educational system to ensure that more equal and universal educational systems are developed and provided across the world.
- The Delors Four Pillars are somewhat theoretical concepts that, to some extent provide boundaries of science-based education however, they do not provide specific classification (*themes of Education* which is provided as a part of the proposed 21st century model) of the significant issue in education. Some of the possible classifications could include specific teaching pedagogy such as science-based. Delors' model needs to clearly show these specific categorizations, not only for ease of understanding but also for better future-planning.
- Although the Delors Pillars consider human behavior and some external influences such as the community, responsible authorities and governments, they do not include some of the most recent yet fundamental instruments of education, such as specialized educational institutes. Specific education such as science-based is one example in which Delors' report needed to research further and provide more details about.
- The need for better workplace readiness: Although Delors also covers this issue; he does not provide a diverse range of options. McLean (2006) argues that "*at universities and training colleges the students have been taught to know, but have not been allowed to feel*". This is another significant indication of teaching students the 'ability to do' what they have been learning, is absolutely fundamental especially for science-based programs. As our societies are constantly expanding, the classification of education needs to be revised regularly to display a more close relationship with the industry. This requires the students spending some time actually working to see first-hand what they are being taught. In addition, the staffs also need to revisit their work practices to ensure that the students are aware of the current procedures that are unique to each profession. As an alternative to universities, TVETs and TAFEs provide a hands-on experience, which the future employees need to possess.

These skills need to be updated on a regular basis to represent the industry needs and the economic trends. As a part of this work-ready philosophy, there must be supportive and sufficient collaboration with industry to successfully plan and implement current and relevant work practices.

The next section provides the Pedagogy Modeling for Science-Based Subjects, which is guided from Delors' pillars of education.

4.0 PEDAGOGY MODELING FOR SCIENCE BASED SUBJECTS

As mentioned above, although Jacques Delors has investigated and explored the main areas of education in detail, the discipline has gone through some fundamental changes since 1996. The proposed Pedagogy Modeling for science-based subjects considers all the relevant and important aspects of specific education, not only in today's current climate but also for the foreseeable future. More importantly, as the educational system goes through rigorous changes, there are some fundamental matters that need to be carefully considered. These issues can be referred to as Science Based Parameters (SBP) and include:-

- **Flexibility:** This includes flexible course delivery; a concept that involves offering quality-assured, accredited education programs that contain what students need, when and where they need it, and at a cost they can afford. Furthermore, flexible delivery denotes mature-age students (aged 21 or older) can study part-time or full-time, from home or work, and from anywhere in Australia or overseas.
- **Industry Links:** This is the most significant issue for science-based programs, and all educational institutes need to maintain strong industry links. This could be achieved via joint research and educational programs, which allows students to have the opportunity to be involved in industry projects and work experience. As part of this close collaboration, companies could sponsor student awards annually and graduates enjoy high employment rates.
- **Multi-Skilling:** The study programs must be designed to produce graduates that are work-ready. This means developing graduates who are multi-skilled, broadly focused with multi-disciplinary technical competence as in science-based programs, and the ability to take a systems approach to design and operational performance. This includes developing interpersonal and interpersonal skills such as effective communication, teamwork and technology management, and a holistic understanding of the role of the professional in society.
- **Professional Accreditation:** The provided programs need to be fully accredited by the relevant industry professional association. These professional accreditations mean that the students are recognized as professionals, not only nationally but also internationally, endorsing that what the students are internationally recognized.

The following figure (figure 3) represents the proposed Pedagogy Modeling for Science Based Subjects.

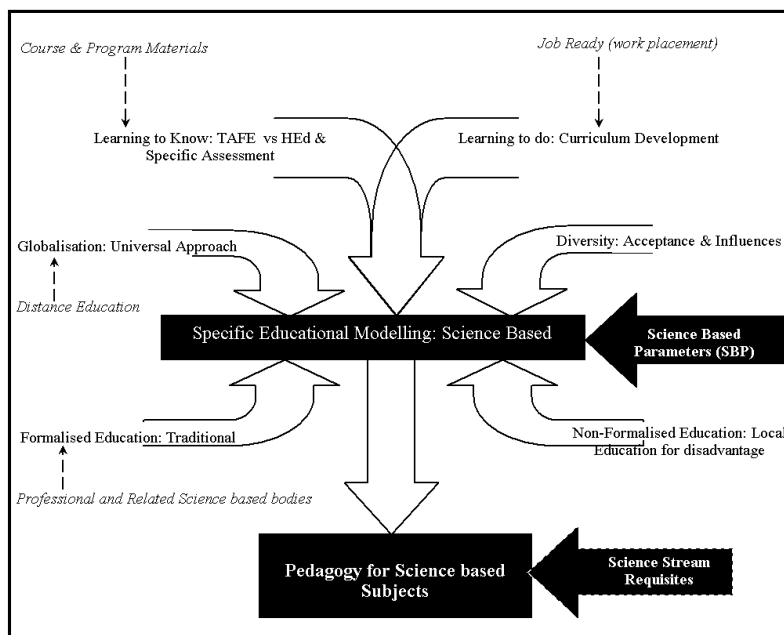


Figure 3: Pedagogy Modeling for Science-Based Subjects

As it can be noticed, the developed pedagogy model has utilized the Jacques Delors Pillars of Education as the basis of the design element. This model is developed for science-based subjects and courses, and has included the relevant elements that were previously discussed. As mentioned before, the current literature for teaching pedagogy does not cover any specific model that is solely designed for the unique requirements of teaching scientific subjects. Instead, the current literature treats most disciplines as one, and thus there are no specific educational models specific for unique requirement of science-related subjects. Furthermore, the proposed pedagogy model considers all the relevant and important aspects of education, not only in today's current climate but also in the foreseeable future. Essentially, as science-based subjects go through rigorous changes to maintain it with industry requirements, the educational system needs to be flexible to accommodate for these inevitable changes. In addition to flexibility, science-based educational systems need to carefully include specific industry links, multi-skilling and professional accreditation targeted towards each particular field of science.

In addition, as it can observe, all the discussed issues are input into the Specific Educational Modeling: Science Based stage. And finally the science stream requisites are implemented, and hence the pedagogy for science-based subjects is established. It is important to note, that science stream requisites is an intentionally independent variable to provide the flexibility required (as discussed before).

5.0 CONCLUSIONS

In summary, education is a human right and everyone has the right to have access to it. Education broadens skills in case of changes or preferences in future employment. Effective education needs to be reflective-based on the required work skills, not only via formal but also in-formal education. The relationship between education and employability is very close. Effective education through life-long learning updates knowledge and establishes new skills via methods such as "learning on the job" methodology. Methodologies such as 'learning on the job' combines training and education to equip better science-based employees such as medical doctors, nurses, and engineers. Such professional enhancement tactics not

only update and modernize people's skills, but also improves the community's productiveness. Although currently such training education is offered via universities and TAFEs (in Australia), there are more needs for such training organizations world-wide. This requires the implementation of specific educational modeling which embraces the educational issues of the 21st century and beyond.

In conclusion, this report was based on the Jacques Delors Four Pillars of Education, and has proposed new and innovative pedagogy modeling for science-based subjects, which include the involvement of specific educational issues in the 21st century and beyond. In doing so, some fundamental issues such as equal education (education for all), sustainable education, teaching pedagogies (formal and informal education) were researched, analyzed and discussed. As stated, the proposed pedagogy modeling for science-based subjects is mainly created in correlation with the Jacques Delors Pillars of Education. Based on the Delors Pillars, the "Themes of Education" (sub-classification of the points already referred to by the Delors report) is developed to categorize various aspects (of Delors' Pillars of Education) into more relevant and specific sections. It is hoped that the developed pedagogy provides an optimized evaluation and offers sound recommendation for an effective and operational educational system for the 21st century and beyond.

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