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Uploading the Workload: E-materialization Processes Based on Knowledge Economy in Higher Education*

İşgücünün Yüklenmesi: Yüksek Öğretimde Bilgi Ekonomisine Dayalı E-Materyal Geliştirme Süreçleri

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Abstract

Universities as distinguished representatives of higher education bear great responsibilities for providing quality and innovative perspectives to their individuals. Costs and benefits of distributing high quality knowledge equally and of the best quality suggest a merge of some concepts such as learning or knowledge with economic resourcefulness in regard to cost-effectiveness. Basic instructional instruments such as syllabi, curriculums, presentations, and course notes are essential in realizing educational targets and achieving desired success. Traditional processing and application of these tools slows down efficient and quick access to learning and teaching activities. In this regard, e-materializing these instructional dynamics creates an accelerated and facilitated progression of educational activities. Overall, this study aims at developing an insight into past and current developments and applications regarding knowledge, information and data transformation processes in higher education in the sense of economic efficiency, usability, and productivity for achieving an innovative learning environment. Based on the relevant literature, this analysis first of all introduces basic concepts such as knowledge and information. Based on the tripod of education, economy, and environment, the study defines e-materialization channels in higher education and it further questions possible ways and technological tools for achieving an enhanced cost-effective learning setting in the digital world of education. Discussed in different aspects, further analyses were made concerning the suggested approach for an effective and economical transformation and use of educational knowledge and sources. Finally, an overview of the subject was provided for further discussions that will pave the

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way for maintaining a cost-effective and efficient learning environment for higher education with new concepts and forms.
KeyWords: Knowledge Economy, Learning Economy, Cost-effectiveness, E-materialization, Technology, E-learning, Environment, Educational Green Data.

Özet

Yüksek öğretimin seçkin temsilcileri olarak üniversiteler bireylerine kaliteli ve yenilikçi bakış açıları sunma konusunda büyük sorumluluklar taşımaktadır. Böyle yüksek kalitede olduğu kadar en iyi bilgiyi sunma, uygun maliyet açısından ekonomik kaynak zenginliğine bağlı olarak öğrenme ve bilgi gibi kavramlarının bir bileşiminin kullanımını öngörür. Müfredat, ders programları ve ders notları gibi temel öğretim araçları eğitimsel amaçlarının gerçekleştirilmesinde ve istenilen başarının elde edilmesinde önemli rol oynamaktadır. Bu araçlarını geleneksel olarak işlenmesi ve uygulanması eğitim ve öğretim faaliyetlerine olan hızlı ve etkin ulaşımı yavaşlatmaktadır. Bu bağlamda bu öğretim dinamiklerinin e-materyalleştirilmesi eğitim faaliyetlerinin hızlandırılmış ve kolaylaştırılmış şekilde ilerlemesini sağlar. Genel olarak bu çalışma yenilikçi bir öğrenme ortamının yaratılabilmesi için ekonomik yeterlilik, kullanılabilirlik ve üretkenlik anlamında yüksek öğretimde edinilmiş bilgi (knowledge) ve aktarılmış bilgi (information) ve veri dönüşümü süreçlerine ilişkin geçmiş ve mevcut gelişim ve uygulamalara ilişkin bir öngörü geliştirmeyi amaçlamaktadır. İlgili literatüre dayanarak bu analiz öncelikle edinilmiş bilgi (knowledge) ve aktarılmış bilgi (information) gibi temel kavramları ortaya koyan bir giriş yapar. Eğitim, ekonomi ve çevre gibi üçayak üzerine oturtulan çalışma yüksek öğretimde e-materyal geliştirme kanallarını tanımlayarak dijital eğitim dünyasında uygun maliyet ile öğrenme ortamları geliştirmenin olası yöntemlerini ve teknolojik araçlarını sorgular. Çalışmada farklı açılardan tartışılarak eğitim bilgi ve kaynaklarını ekonomik ve etkin dönüşümüne ve kullanımına ilişkin önerilen yaklaşım doğrultusunda analizler yapılmıştır. Son olarak, araştırma genel bir bakış açısıyla değerlendirilmiş ve gelecekte yüksek öğretimde yeni kavram ve formlar ışığında uygun maliyet ve etkin öğrenme ortamlarının sağlanmasına yönelik tartışmalara yer verilmiştir.

Anahtar Kelimeler: Bilgi Ekonomisi, Öğrenme Ekonomisi, Maliyet Uygunluğu, E-materyal geliştirme, Teknoloji, E-öğrenme, Çevre, Eğitim Yeşil Verisi.

Introduction

In this very world of today with immense and rapid information flow, there is no doubt that yesterday's awakening is and will be totally different from today's in that every passing day we are astounded by another "the latest and newer version" of concepts and forms that come with technology. We live in a society that is more of a "webbed society" with less and less detachment from interactivity and a mass communication. With its democratic nature, we live in information society; a society providing universal access to information for everybody.

Adding to this point, Aktaş (2012) stated that:

> Electronic democracy, improvement in education and training, betterment of employment, support of market economy, various legal and social benefits and finally research and development improvement may be named as a few of the advantages of information society. A

> new paradigm is emerging creating knowledge-based economies and societies. Knowledge is becoming the main source of wealth and power (p. 4).

Knowledge based society of today reinforces all the dynamics in itself towards building up a prosperous and communicative form of interaction among its members. Methods and approaches as to how economic, educational, environmental sectors deal with knowledge processing in the most efficient way have been in rapid progress quite recently.

Knowledge

Acquiring knowledge is a cumulative process that we take over from our ancestor and pass down to the next generation. Early man's ability in making fire was a tremendous advance transmitted within and among tribes. Later, knowledge accumulated by primitive societies about plants, animals, and minerals was essential to their survival for thousands of years (World Bank Development Studies [WBI], 2007). In that sense knowledge is the oldest form of mankind's possessions.

Collins Cobuild Online Dictionary (2012) defines knowledge as "*information and understanding about a subject which a person has, or which all people have*". One characteristics of knowledge is that it comes to us through our senses. Knowledge involves the mental processes of comprehensive understanding and learning. Knowledge is the richest resource at any organization's disposal, and all learning organizations know that the collective and individual knowledge of people is their cutting edge (Cheema, 2010). The need for gathering, storing, updating, disseminating or generating knowledge in the most effective and economical way cause institutions to reorganize their information processing and management systems accordingly, which recreates the term "the economy of knowledge" or "knowledge economy".

Knowledge Economy

According to Powell and Snellman (2004), "a knowledge economy is production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence. Adding to this point, *over* the past several decades, a number of scholars and commentators have argued that the leading edge of the economy in developed countries has become driven by technologies based on knowledge and information production and dissemination. The key components of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources" (pp. 199-220).

According to Kahin and Foray (2006), "the aim of the economics of knowledge is to analyze and discuss institutions, technologies, and social regulations that can facilitate the efficient production and use of knowledge" (pp. 27-29). Srlin (2006) believed that "there are many discussions of the ways in which knowledge is shaped according to the field or tasks to which it is directed" (p. 44).

As Uçkan (2006) stated that:

> Generation, processing, sharing, circulation and management of knowledge as the basic input of production are new concepts in which it has relatively become the dynamics of human and economic development and global competition. These concepts find their way in knowledge economy. Knowledge economy can be described as both a production of current socio-economic tendencies and a political choice or vision (pp. 23-48).

In the statements of Houghton and Sheehan (2000), in a knowledge economy:

> The key resource is knowledge where firms search for linkages to promote inter-firm interactive learning. Through these relationships firms can spread the costs and risks associated with innovation, gain access to new research results, acquire key technological components, and share assets in manufacturing, marketing and distribution. As new products and processes, are developed, firms determine which activities they will undertake individually in collaboration with other firms, universities or research institutions with the support of government. Innovation is thus the result of numerous interactions between actors and institutions, which together form an innovation. Relationships existing among industry, government and academia help the development of science and technology. Universities are the best examples of this that display a blended setting for learning with all the innovative, educational and scientific activities that are meant to be cost effective and also environmentally friendly (p. 14).

Learning Economy

Based on the view of Gregersen and Johnson (1996):

> Learning economy, in a sense, all economies are knowledge-based. Even so called primitive economies have depended on complicated knowledge structures, partly stored through traditions, habits, folk-ways, and rites, which have made living in often harsh environments possible. Any knowledge-based economy has to develop ways of storing its knowledge but it does not always have to utilize it very intensively or turn it over very fast. In a learning economy, on the other hand, the rate of knowledge turnover is high; learning and forgetting are intense, the diffusion of knowledge is fast, and a substantial part of the total knowledge stock is changed every year. Furthermore, learning has become increasingly endogenous. Learning processes have been institutionalized and feed-back loops for knowledge accumulation have been built in so that the economy as a whole is learning by interacting in relation to both production and consumption (pp. 3-4).

In the new learning environment, teachers and trainers work as facilitators, enabling learners to access knowledge and develop their conceptual understanding. Creating this new environment requires a change of culture, especially where teachers' status in the classroom and society arises from being perceived as an authority figure. Traditionally, teachers were learners only

during pre and episodic in-service training. Today they need to be lifelong learners (World Bank Report, 2003).

Learning and Innovation

As Gregersen and Johnson (1996) before "learning is connected to innovation. Put in a very simple way innovations are regarded as 'learning results'. Learning leads to new knowledge and entrepreneurs of different kinds use this knowledge to form innovative ideas and projects and some of these find their way into the economy in the form of innovations" (p. 4).

The result of the empirical analyses that is consistent with the hypothesis in Seki and Barbaros' (2011) study showed "that the countries that have relatively more powerful higher education sector are more efficient in innovation process and also they have more competitive power than their competitors".

The Role of Higher Education Institutions in the Knowledge Society and Knowledge Economy

The generative core of new knowledge is to be found in the education and scientific sectors, mainly in the universities. Historically, universities have been the institutions where knowledge is produced, nurtured and protected. It is mainly at the universities where the abilities to produce knowledge and its application are generated.

A knowledge society and universities go hand in hand. The role of the university in the accelerated generation of knowledge has been one of the most powerful axes to have shaped the new configuration of society. Simultaneously, the knowledge society is having an impact on the traditional life of universities.

With this in mind we can understand the transformations of the universities, including those related to the modification of their organization and work practices as well as those that have transformed the relationship of the institutions with the contexts in which they are inserted. For example, today scholars join and generate circuits of knowledge between the university and the external world in search of funding for their projects.

Higher education is obliged to answer to the needs of countries but it is also obliged to respond to the demands of globalization and aim towards the achievement of a greater convergence of human understanding. In this sense, international cooperation is a unique condition to improve the quality of higher education institutions.

Within the context of the knowledge society, the strengthening of higher education must be a strategic priority for every country. Support to universities, mainly those that are public, should be absolute since it is in these institutions where knowledge is fostered and guarded and the democratic values that characterize democratic societies are recreated and conveyed. Hence, it is necessary to reinforce the civilizing function of universities. There is no future without education, but an education without civic values is only mere information and is therefore incomplete (Robles, 2011).

Desrochers (2006) points out that "to maintain economic competitiveness, higher education must continue to play the lead role in educating workforce.

Thus far, education has been "ace in the hole," allowing continued investments in the development and exploitation of new technologies that increase productivity growth, and ultimately, economic growth" (p. 3).

E-materialization

In various literatures, seemingly being a newly adapted term *"e-materialization"* in one sense refers to "*the substitution of electronic media for a physical product* (Internet Innovation Alliance, 2012). Wilsdon's (2001) glossary defines e-materialization as "*reducing material and energy inputs through information technologies*" (pp. 202-204). Related to internet economy, (Wilsdon) used the term to be referred as "something that can turn buildings into websites and replace warehouses with supply chain. It can turn paper and CDs into electrons and replace trucks with fiber optic cable. That means significant energy savings" (p. 82).

A different source describes e-materialization as a term that refers to the substituting emailed/website information for information mailed to your home or office. Similarly, it also means replacing physical goods, information with electronic versions of them (Consumer Electronics Association [CEA], 2007).

On the other hand "dematerialization" is another term that seems to bear a similar meaning to e-materialization in that "dematerialization" can be described as an electronic transfer of a product literally, also means less, or better yet, referring to the absolute or relative reduction in the quantity of materials required to serve economic functions in society. In common terms, dematerialization means doing more with less. Sharing common purposes, it is clear that e-materialization differs from dematerialization in that the former relates to the efficient use of information technologies in achieving the same tasks.

In our study we prefer to attribute information (knowledge) transformation and economy to e-materialization processes to avoid a conflict of concepts and meanings.

Speaking about new economy, Zadek (2001) implies that "new economy is a source of hope, delivering a safe natural environment secured through e-materialization, progressive work opportunities complete with family and community synergies, and a democratic renaissance based on technology-enabled direct citizen participation".

Pociask (2011) outlines the effects of information technologies on six different areas such as E-commerce, E-materialization, Telemedicine, Teleconferencing, Distance Learning and Telecommuting. The graph below shows savings in terms of greenhouse gas reductions obtained from the use of information technology (pp. 15, 24).

Table 1.

Greenhouse Gas Reductions

E-commerce: B2B and B2C	206.3
Telecommuting: Direct and Indirect	588.2
E-materialization	**67.2**

Telemedicine	Not
Teleconferencing	199.8
Distance Learning	**Not**
TOTAL	> 1,000

*24 *Cumulative 10-Year Forecast in Millions of US Tons* Source: ACI

As also noted in the graph, data related to greenhouse gas reductions for distance learning is missing whereas similar data for e-materialization can be forecasted. This scenario shows us that e-materialization processes within e-learning can be disseminated in a way by which future projections can be drawn to shape an innovative, cost effective and environmentally friendly learning.

E-materialization Channels in Higher Education on the Tripod of Education, Economy and Environment

Being at the top of the educational institutionalization in higher education, it is clear that universities have the leading role in guiding the society. For that reason, governments need to attach great importance to setting up the most efficient, time-saving, cost-effective and economical form of a learning organization. To do this, innovative learning through information technologies seem to be the most attractive and practical solution. Although many universities do not even hesitate to transform their learning, few seem to make thorough projections about how cost-saving and cost effective it could be to e-materialize their learning. Such limited statistical data about this transformation process and the urgent need for it maintain the framework of our objectives in this study to be able to shed a brighter light on the initiation of a possible future modeling. By e-materializing their sources, knowingly or unknowingly universities also contribute to not only learning environment but also natural environment, which is becoming an eye-catching and sensitive issue in the realization of an environmental friendly form and use of technologies in the learning process. This also recalls a metaphoric concept like recycling learning or recycled learning.

Converting a classroom setting with all the instructional materials (boards, desks, chairs, books etc.) and instructional services (course and syllabus design) into an abstract form and making it reachable by masses are challenging attempts and procedures. By all means, the whole process signals an intensive transformation process so much as all the means of e-materialization are concerned. This can be realized through some main channels where e-materialization is the main actor and performer in such transformation and distribution of an innovative education design. These channels can be listed as:

Distribution of Learning and Teaching: Distance Education: Bringing learning online by **i**mplementing efficient online assessment process for exercises, quizzes, and tests to reduces faculty labor in preparing, grading, recording assessments and posting results. According to Cukier's (2006), "comparative approach comparing technology-based course delivery with traditional face-to-face delivery, it is most useful when the same course is delivered using both teaching means. However, while evaluating different

courses, direct comparisons are more difficult. The main advantage of the comparative approach, especially when comparing one technology to another, is that it can provide guidance for on-going management decisions about existing technology uses in education" (pp. 137-152).

Trainings: Professional development in higher education is highly essential as universities are main information centers that promote lifelong learning. Staff and academics trainings can be long and costly procedures whose outcome can be seen on the long run. Traditionally, most training takes place on site and face to face as they may require hands-on practice. Mobility is another option in which trainees are sent to different locations to get the training. On the other hand, both of these choices can be time consuming and affect productivity resulting from reduced man power. In that case, universities resort to innovative tools to facilitate this process by designing an online program setting. Video or tele-conferencing and Webinars, short for Web-based Seminar, a presentation, lecture, workshop or seminar have been one of the most common tools used in professional trainings. Projecting the costs and benefits in realizing an e-training program is a highly essential issue.

Student Services: Registration, Evaluation-grading and Tracking: By initiating an efficient course management system that allows faculties to record and calculate grades, changes in syllabi, etc., amount of faculty time spent on administrative tasks is reduced. A lot of paper work circulating in a student affairs office can now be reduced to the minimum by implementing a carefully planned e-materialization process. Student tracking systems operating on mobile devices enable students to follow grades, courses, announcements and academic progress with no obligation to be on campus. Reducing commute to the campus also helps gas emissions. Related cost effectiveness analysis is referral to student services performance and environmental benefits.

Libraries as Information Centers: Databases: In traditional sense libraries are buildings full of books where one has to be present in person to benefit from hard copy sources. By changing technology, millions of books have been transformed into digital copies that can be reached from anywhere in the world. E-materialization of the hard copy sources in a library and publishing them online require careful planning and organization with high tech instruments. Such libraries acting as databases serve extensive academic research and purposes. Creating a hard copy source can be as much frustrating and costly as delivering it online. Instead, authoring it online will reduce the number of stages to be followed on the way to the user. Less paperwork means more environmental protection. In that sense, like academic buildings, libraries will operate as green data centers designed for maximum energy efficiency and minimum environmental impact.

Related Research

The research on using e-materialization processes named after various definitions dates back to the first formation and initial combination of technology and education. Cost-effectiveness analysis and formulations have been a great

concern for researchers in dealing with creating effective process and transformation of knowledge in educational institutions such as universities.
Bartley and Golek (2004) pointed out that:

> Universities and corporations are in precarious economic positions at the current time with high emphasis placed on cost reductions in any manner possible. Determining the cost of online learning is an essential component in deciding whether these new techniques are appropriate for a particular organization. In addition to examining the value added components for learning, one must also consider the cost, and whether these costs are justifiable. The Return on Investment (ROI) calculation has been presented in the training literature in a number of sources. Simply, the ROI calculation requires only knowledge of the net program benefits and the program costs. A ratio of these two numbers indicates the return on investment. One of the reasons that trainers often fear making this ROI calculation is fear that the net program benefits cannot be accurately predicted (pp. 167-175).

In weighting the cost of an educational alternative, against its outcomes Levin and McEwan (2000) suggest that "there are three analytical approaches. These outcomes are *cost-effectiveness, cost-utility,* and *cost-benefit.* They are similar in one important respect: Each method relies upon cost. Cost-effectiveness analysis compares two or more educational programs according to their effectiveness and costs in accomplishing a particular objective. In a cost-effectiveness analysis, the cost effectiveness ratio (CER) of each alternative is obtained by dividing the cost of each alternative (C) by its effectiveness (E):

$$CER = \frac{C}{E}$$

It is interpreted as the cost of obtaining an additional unit of effectiveness (however this is defined by the evaluator). When ratios are calculated for each alternative, they should be rank-ordered from smallest to largest"

In comparing Web-based distance education and classroom course delivery, there must be a clear basis for measuring output. It can be argued that the true measure of training output is the information and skills acquired by students. For the present costing analysis, the basis for comparison will be the costs of development and delivery of the courses themselves. In analyzing the costs of Web-based courses, the basis for comparison is the cost of delivering an equivalent course in the classroom. Costs are divided into fixed and variable costs in order to compare technology-enabled learning to traditional classroom delivery. Fixed costs are defined as costs that remain the same regardless of the output. Variable costs are those that vary directly with the amount of output. Thus, variable costs increase with the number of students, while fixed costs are incurred before a course is even offered. Clearly, costs that would be incurred even if a course were delivered in a classroom (i.e., sunk costs) should be ignored in costing Web-based training. For example, if a course were previously offered in the classroom, and no further research and development for course

materials were needed, the cost of creating the intellectual property for the course would be a sunk cost.

Although few cost-benefit analyses for Web-based training are available, standard measures of financial performance apply to this type of study. Two common measures are the breakeven point, the point at which costs are recovered, and return on investment, which illustrates the economic gain or loss from having undertaken a project.

To offset the high fixed costs of Web based courses, a certain number of students must be trained at a delivery cost per student of less than that of the delivery cost per student for classroom training. The number of students that offsets the fixed costs of Web-based training is the breakeven point.

In Figure I the total fixed costs for classroom and web-based courses are represented by the intercepts of the vertical axis.

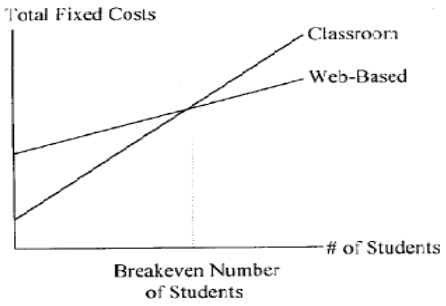

Figure 1. Breakeven Number of Students

The cost of course delivery per student is represented by the slope of each line. Since Web-based courses cost more to develop, the line meets the vertical axis at a higher point than for classroom costs. However, since Web-based courses cost less to deliver per student, the slope of the line **is** more gradual. The point at which the lines cross is the breakeven number of students needed to recover the higher fixed costs of Web-based delivery.

Costing Methodology

Web-based training has become a widely explored and studied topic in the education and training literature. There are several key design elements that must be costed in a majority of web-based training projects. According to Whalen and Wright (1999), "these costs are divided into fixed capital costs and variable operating costs. Capital costs include the server platform shared by all courses mounted on that server as well as the cost of the content development shared by all students taking that course. To verify the costing methodology, it is necessary to determine whether some of these costing elements are more important than others" (pp. 25-43).

Since distance education relies on technology to deliver instruction and support the learner, it can be argued that a great part of its cost is that of technology (e.g., equipment, materials, operation, etc.). Costs vary between institutions according to the type of technology and programmed. Sadik (2009) suggested

that "there is a simple function to calculate the marginal cost for student per hour as follows:
MC=TC(N+1)-TC(N) where: MC is the marginal cost per student per hour TC (N+1) is the cost of the system with after adding a new unit TC (N) is the cost of the system."
Sadik argued that "the total cost function can be approximated using the fixed and the variable costs per student the following formula:

$$FAC(N) = \frac{F}{N} + V$$

where: AC (N) is the cost per number of students F is the fixed cost N is the number of students V is the variable costs." It was also emphasized that "the above function gives a reasonable approximation to the cost behavior of an instructional technology system, making it possible to find the cost for each student, taking into account the fixed and the variable costs, which may not remain constant."
Sadik also presented that "the following function gives the dollar cost per student (students being the unit or the unit of output for distance education) contact hour for an educational technology system, as follows:

$$\$ = \frac{t}{h \times n}$$

where: $ is the cost per student contact hour t is the total of the variable costs h is the average of studying hours n is the total number of students who studied the course". Sadik argued that "this function may be useful for estimating the costs before a project begins, or for evaluating the costs and benefits of a whole system". Considering the earlier approaches for defining costs, Sadik suggested "that there is a cost function estimating the total cost of using broadcasting. This function has been given as follows:

$$TC=C_C+C_P+C_T+C_R$$

where: C_C = central costs (costs of research, planning and start up the programmed) P_p = programming costs (production equipment, facilities, etc.) T_T = transmission costs (transmission operation and equipment) R_R = reception costs (receivers, power, etc.) Using recent technologies which have the ability to accomplish high-level objectives of interaction and support for distance education accompanied by high fixed costs, these costs tend to fall due to the long time of use and the number of learners who can be reached worldwide".
Economic management strategies and policies in a country should also observe and support current and future investment analyses and projection in different fields. Higher education is an area in which a lot of economic concerns should be projected and reflected accurately timely on educational services that are to be distributed to the receivers. Although more and more private (foundation)

and government-free universities are being established all over the world, their number of still falls behind public universities. Cost effectiveness in transforming and managing education in higher education is often underestimated by many governments. As huge bodies of knowledge and governance, universities and consequently their budgets are difficult to control. Therefore, without bias, entrepreneurial and innovative attempts to modernize education through latest technologies should be realized through a financial planning. Universities need to develop e-materialization costs analysis unit where efficiency and cost effectiveness in setting up technologically advanced are studied, analyzed and projected through knowledge- information and learning economy principles.

Research Question

Based on the results of research in the literature, the study aims at developing an eclectic approach that defines e-materialization channels in higher education through a formulation and it further questions possible ways and technological tools for achieving an enhanced cost-effective learning setting in the digital world of education.

Founded on the tripod of education economy and environment, our approach in this study suggests that in producing and distributing learning services, universities should regard learning as a process whose outcome needs to be based on not only learning efficiency but also cost efficiency. From such a dual harmony, environment-friendly impacts will be indispensible. In this respect, overall, our suggested equation reads as follows:

$e\text{-}M\ (ESC_n) = (E_u + EF_v) - CE_a$

An e-materialization (e-M) process that can be realized on a number of Educational Service Channels (ESC) equals to the sum of measured Educational utility ($E_{u)}$ and Environmentally Friendliness value (EF_v) subtracted from Cost Effectiveness analysis (CE_a). To give an example, taking the decision to transfer a physical library into a virtual data center depends on measurable rather than hypothetical data on utility and value collected through needs analysis along with environmental concerns through energy savings.

Conclusion and Discussion

Universities as higher education institutions should be regarded non-governmental civil organizations that can run and survive on their own assets and sources in the most efficient, beneficial and cost effective way as far as instructional activities are concerned. A well-organized and designed e-materialization process will help universities transform and transfer their services and products in the most economical and efficient way in which they will be saving a lot for their future educational investment. Next, from a global perspective, universities as leading academic units in a knowledge society can neither neglect nor hesitate about ecological threats and problems facing the world. Thus, their involvement in e-materialization initiatives in higher education will directly or indirectly produce positive and environmentally friendly results.

Suggestions for Future Research

- Our understanding of "digital data" can now be specified and distinguished as "green data." Building green data centers in higher education institutions that will work for maximum energy and cost efficiency and minimum harmful environmental impact related to educational activities and operations can be a critical step in achieving time and cost savings both in the short and long term.
- A higher education institution equipped with state of the art technologies and utilities can create an ideal platform that combines server, storage, network, and management components. Comprehensive, simplified, but orchestrated management of data can eliminate the guesswork related to new infrastructure or services concerned and involved in that process.

Issues of infrastructure design and operations involved for building "educational green data centers" in this study were partially mentioned but intentionally left incomplete for the concern of future studies.

The fact that e-materialization process in the current literature has been mainly attributed to issues concerning environmental transformations and savings limited the scope of this research as far as educational use and benefits of e-materialization are concerned.

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