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Impact of computer graphics on the engineering product design: Conceptual analysis

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Computer graphics matured over many years and played an important role in the development of engineering products like automotive and aircraft components. The current CAX (CAD/CAM/CAE) tools use computer graphics extensively, while helping in conceiving better designs with improved quality. Nowadays, engineering product development is being done concurrently and collaboratively, due to the advances in computer graphics. This paper presents a brief overview on evolution of computer graphics over the decades and its impact on the engineering product development. Conceptual analysis is done in order to find out the impact of computer graphics on engineering product development. It also attempts to present, how advances in computer graphics, have revolutionized the current engineering product development and what future technologies will offer.

Key words: Computer graphics, engineering product development, computer graphic sciences.

INTRODUCTION

No matter how an idea is scratched or originates in the shape of untraced drawing on a napkin, meditation in graphic design is principal. According to Berkun (2000) of Microsoft failed ideas should “draw on sketch paper or in samples, not in the invention, and you can only do that by disbursing the energy to discover lots of ideas”. Outlining ideas on paper is a vital ability for product design. Albert Einstein was cited as saying “the physicist’s greatest tool is his wastebasket” and his Theory of Relativity activated as a draft on an argument of paper (Lawrence, 2005).

Elementary visual skills, which are essential for achievement in graphic design, are grounded on the capability to “mentally invert, manipulate, twist, rotate or pictorially offer graphic stimuli” (McGee, 1979).

The development of graphical strategies for building of machinery and architecture is becoming easier with the use of computer and the Internet. Computer invention and novelty of computer-aided design (CAD) intensely varies how two-dimensional (2D) and three-dimensional (3D) visuals are designed. CAD, which is the use of a wide-range of computer-based tackles for designing and emerging products, is a significant geometry-authoring instrument for product development management. It varies from 2D vector-based conscripting systems to 3D parametric outward and solid design demonstrating systems. In the product lifecycle, a physical sample can be shaped from sketches or from a computer-aided manufacturing system (CAM). The prototype is then verified for design acquiescence and shaped for mass manufacture in the industrial division.

At the time Internet technologies were implemented in the graphic design business in the 1990’s, work in graphic design was modernized. Today’s cooperation has helped advance both higher education and business; also the Internet expedites worldwide communication. Conversely, when we move onward into the 21st century with more scientific inventions, we need to guarantee that we take with us the art of free drawing as an appreciated instrument for the picturing procedure.

Furthermore, the computer graphics tools not only

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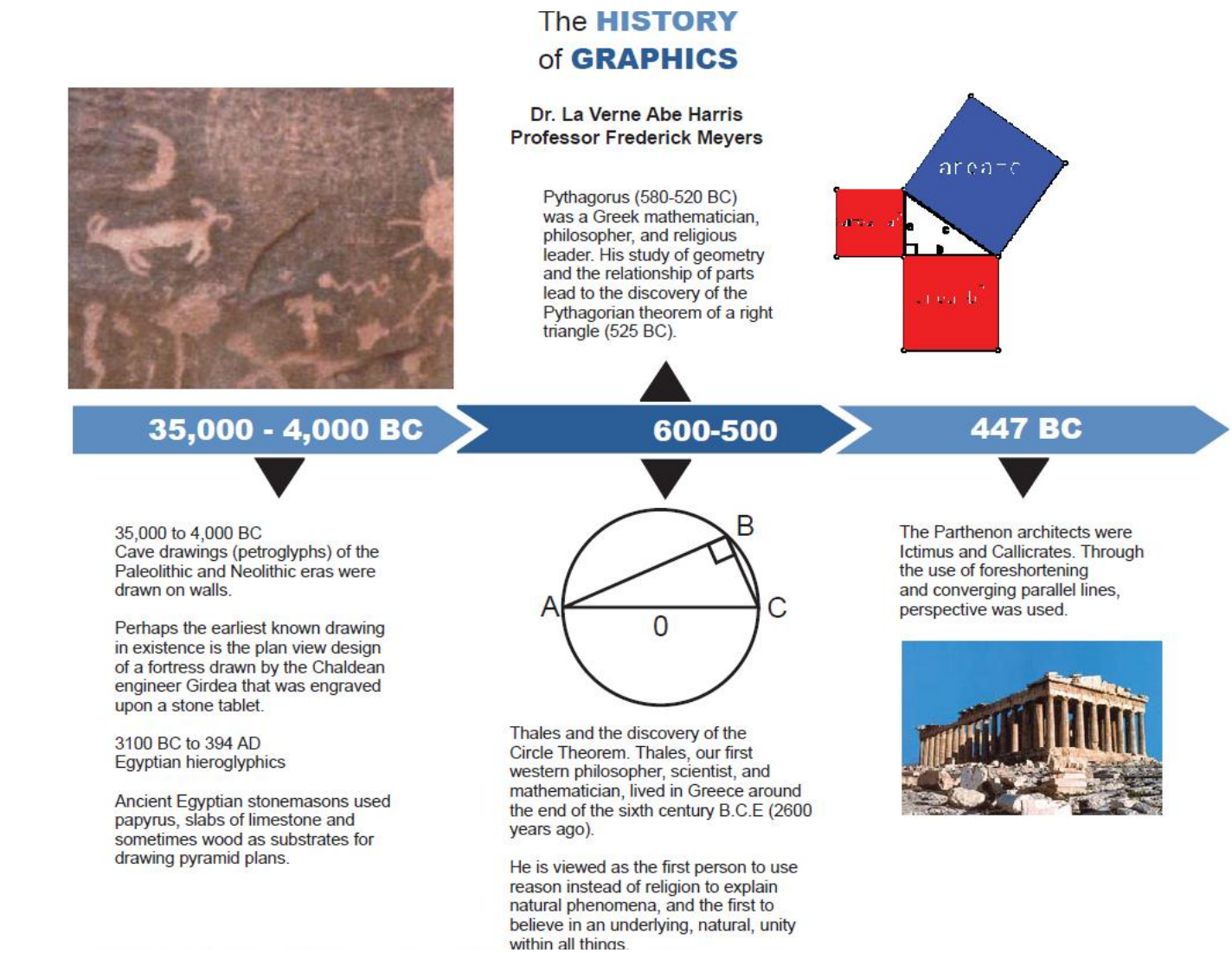

Figure 1. History of graphics - Early visualizations.

fulfill the accuracy of the creation or invention of engineering products, it also facilitates the customers' checking of the engineering product as an end product even before its development starts. This allows manufacturers to boost up their engineering products sales effectively, and as this computer graphics permits them to make a real time product on the computer as well as present it to the customers. Moreover customers can also demand for some modifications or alterations in those designs, so that it could be created or invented exactly according to the needs or requirements of the customers.

This study inspects the timeline of how graphical plans for construction of machinery and architecture have developed through history. This boost the impact that developing technologies have on the graphic product development.

EARLY VISUALIZATIONS

The initial recognized engineering drawings are from a Chaldean engineer named Girdea, who scratched a stronghold idea view on a stone tablet about 4000 B.C.E. The tablet, which is an indication of the solicitation of initial picturing, is on exhibition in the Louvre in Paris and has completed their strategies for pyramids on wood, papyrus, or stone. In the 5th century B.C.E, geometry was being created in Greece by mathematicians together with Archimedes, Pythagoras and Euclid. Greek architects persistently progressed in techniques, as well as perspective, for structures such as the Parthenon through the 4th century B.C.E (Meyers, 2007) (Figure 1).

In the latest centuries B.C.E, a Roman architect, Marcus Vitruvius Pollio inscribed a ten-volume dissertation titled De Architecture. This was seemingly

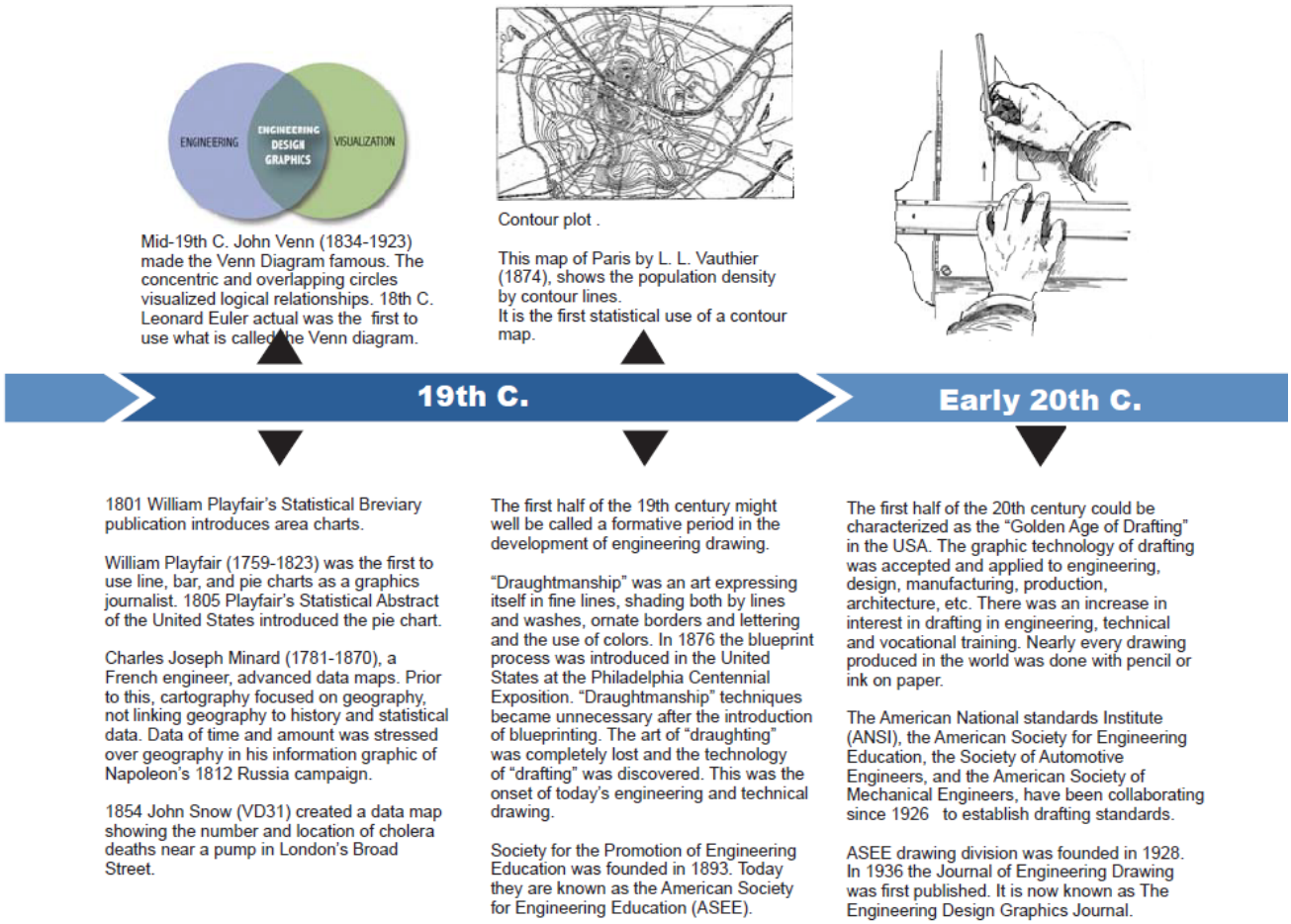

Figure 2. 20th century changes.

lost in the middle Ages and revived in the 15th century. It continued as a valued text till the 19th century. Amongst other things Vitruvius noted scopes for drawing circles in his treatise.

Earlier in that century, Leonardo Da Vinci formed mechanism and architectural drawings, which demonstrate ability and inventiveness, respected to this day (Collins, 2006).

In the 18th century, Gaspard Monge, a French mathematician and designer, placed out the ideologies of descriptive geometry that solved numerous glitches deprived of boring designs. His effort was measured so significant by the French administration that it was reserved as an armed secret for nearly 20 years. By 1795 he helped establish a university for training engineers and issued a text based on his addresses (Reynolds, 1978).

The United States Military Academy (USMA) developed a center for graphics in the United States. Christian Zoeller brought graphic sketch classes to the Academy in 1807. Another faculty member of the USMA, Claude Crozet, presented descriptive geometry to the Academy in 1816. Crozet is also recognized with presenting the blackboard and chalk for the teaching of graphics.

Engineering methods for robust product design, such as Taguchi methods in technology and product development are intensively used in the era of 1990's, as these methods are widely acceptable and ease to use. By using these techniques one cannot only be able to produce the designs according to the customer demands, but to facilitate its customers with more efficiency (Fowlkes, 1995).

Many companies around the globe particularly in USA realized that if they would be able to develop the engineering products more effectively and efficiently then it will ultimately give them a competitive advantage. Therefore they have started using the computer applications in order to develop the engineering products more effectively and efficiently and ultimately to get the competitive advantage (Otto, 2001).

Two key developments encouraged graphics in America in the final half of the 19th century: the Alteneder family formed a factory in Philadelphia for building-up sketching tools and blueprinting was presented at the

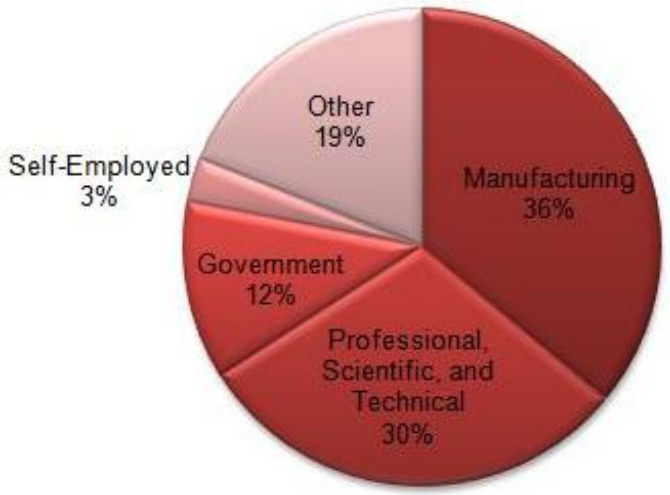

Figure 3. Industries of employment for computer engineers.

Philadelphia Centennial Exposition in 1876. First-class drawing tools no longer had to be introduced, and the "art" of drawing quickly vanished. Earlier in 1876, if extra copies of a drawing were required, the drafter formed every drawing separately. Later in 1876, only one "master copy" was required and as countless blueprints as desired could be made in hours (Land et al., 1976).

1950'S-1990'S: 20TH CENTURY CHANGES

Deadlock in transformation originated as we advanced into the second half of the 20th century. Several universities and governments struggled with the use of huge computers with thousands of vacuum tubes. Mainframes, which were mainly number crunchers, are now being used as graphical computer workplaces.

At numerous universities during higher education, nonetheless, hand tools continued to be used well into the 1990's. Progressively, CadKey was presented for expressive geometry. This application was substituted on the market with KeyCreator (KUBOTEK, 2006).

Main objectives of a research article are to deliver a lifespan of practical usability tasks and techniques for arranging the procedure of designing good products to either traditional software applications or Web pages and applets. The findings present methods which can be functional at diverse points in a typical engineering product development lifecycle (Mayhew, 1999).

The 1950's: A leader appears in academia. Massachusetts Institute of Technology's (MIT) Lincoln Laboratory was a frontrunner in the educational world. They industrialized the first computer graphic system in the mid-1950 for the United States. Computer-processed radar data were exhibited on a cathode-ray tube (CRT) display.

In 1957, PRONTO - the first commercial computer-aided manufacturing (CAM) software system, was industrialized by Dr. Patrick J. Hanratty. This Arizona State University graduate is called the "father of computer-aided design and graphic (CAD/CAM)." His program was a numerical control programming tool (CADAZZ, 2007).

The 1960's: CAD is launched. Three years after 1960, the project "Sketchpad" was formed by Ivan Sutherland with a TX-2 computer as a portion of his Ph.D. dissertation. This MIT Lincoln Laboratory project reflected a milestone to the presentation of the computer-aided design (CAD) industry, and Sketchpad is reflected as the world's first CAD software (CADAZZ, 2007; Sutherland, 1963).

In 1968, original 2D drawing systems were obtainable by means of supercomputers and stations. That same year Syntha Vision was careful to be the first commercial solid modeler program. He intended the likelihood of resolving the demonstrating of complicated 3D forms by means of computers.

Computer visualization, which sold the first profitable CAD system to Xerox, was invented in 1969. Applying production conscripting through CAD systems was the complete mission of Computer visualization.

In 1970's: The foundational code is written. As the decade of the 1970's arose, Hanratty set up Manufacturing & Consulting Systems (MCS). Industry forecasters have endorsed MCS's inventive code to be the basis for 70% of all the 3D motorized CADD/CAM systems (Matson, 2007).

Figure 3 reveals an astonishing view of the industries which are employing computer engineers. Here self-employed are 3%, Government has hired computer engineers around 12%, then professional, scientific and technical industries have hired significant number of computer engineers which are approximately 30%, and last but not least the major number of computer engineers were hired by the manufacturing industry which is 36%.

The first parametric modeling CAD/CAM application and the first high-end solid modeling software bundle accessible on the Windows NT platform was Parametric Technology's Pro/E (version 15) (Figure 4). When we talk about CAD and CAM introduction in the product development of mechanical engineering development, it comprises three main categories, viz: computer science, engineering design and applications, and industrial implementations of these CAD/CAM technology. For instance, if one needs to develop some mechanical engineering products for the use of industries, then these computer-based applications can effectively assist in the graphic designing of those products; it also permits the users to make substantial modifications according to the requirements (Zeid, 1991).

In 1992, Autodesk's 3D Studio and Canvas for Windows

ENGINEERING DESIGN SOFTWARE

YEAR	APPLICATION
1991	Open GL for Windows NT
1992	Autodesk's 3D Studio and Canvas for Windows
	3D Studio version 2 for DOS AutoCAD
	Autodesk's Release 12 for DOS was
1993	SolidWorks
	AutoCAD v. 12 for Windows
1994	Hewlett Packard v. 3.5 PE/Solid Designer
	ArchiGraph's PowerDraw v. 6.0 for Macintosh computers
	HP's PE/Solid Designer (version 3.5)
1995	3DStudio MAX for the NT platform
	CATIA-CADAM AEC plant solutions
1996	Intergraph's Solid Edge v. 3.0
	Solid Works
	Lightscape v. 3.0, a high-end rendering and animation application with Illuminating Engineers Society (IES) standards
	New Tek's Lightwave 3D v. 5 and 5.5
	Intergraph's Solid Edge (version 3)
	SolidWorks
	Corel's CorelCAD
	3D/EYE's Tri Spectives Technical (version 2),
	Lightscape (version 3),
	New Tek's Lightwave 3D (version 5 and 5.5),
	AutoCAD LT 95
	Diehl Graphsoft's MiniCAD 6 for Windows
	Pro/E (version 17)
1997	Autodesk's 3DStudio Viz
	Autodesk's 3D Studio Max (release 2)
	Form Z Window's platform version
	SDRC's IDEAS Artisan Series
1998	Autodesk Architectural Desktop
	IronCAS (version 1.0)
	Autodesk's 3D Studio Max (version 2.5)
	Lightwave 3D (version 5.6)
	Intergraph's Solid Edge (version 3.0)
	Solid Works 98.
1999	CATIA (version 5.0) for Windows NT and UNIX
	New Tek's Lightwave 3D (version 6.0)
	VectorWorks takes the place of MiniCAD.
	(CADAZZ.com, 2007)

Figure 4. Computer graphic design software.

were available for sale. That year industry's CAD/CAMM front-runner award was given to Riddle, and he was designated by Design News as their "Engineer of the Year" finalist (Evolution Computing website, 2007).

CAD customers amplified in numbers during the 1990's. By 1994 AutoCAD had one million customers, CadKey had 180,000, and Micro station had 155,000. Only a year later in 1995, the first website for Autodesk was issued and the customers amplified to three million with 1.3 million Auto-CAD users and 300,000 AutoCAD LT users.12.

By 1997 Canvas software was used to produce designs on Steven Spielberg's The Lost World, and also to demonstrate the Mars Pathfinder.4. The second issue of Autodesk's 3D Studio Max in 1997 was presented into the market along with a concentrated version called 3D Studio Viz. For the next five years, a new version of EDS's Uni-graphics, including WAVE, is well-thought-out to be one of the most notable evolving technologies in the CAD/CAM/CAE industry. Form Z, which was originally only obtainable on the Mac platform, has a Windows platform version released in 1997.

Even with all the scientific inventions in computer graphics design, commercial procedures had a propensity to be resilient to transformation in the 1990's. This aspect has unavoidably unsettled its actual incorporation with computer-based methods. Fresh scientific tools were being used the same way that the ancient apparatuses were used. Workflow required to be incorporated. Creativities required to be established for

business calibration. Once Internet technologies were implemented into the computer graphic design industry, a junction happened and how work was done was reorganized (Fallon, 1998).

Features of Computer Aided Design and Manufacturing (CAD/CAM) Systems are the Digital Design and Analysis Environments, parallel Streams, the Rise of Industrialization and Automation, the computational environment, the Nature of CAD/CAM Technologies, the Manufacturing Environment, an Evolutionary Perspective, the architectural design and the development of numerical control technology (Bechthold, 2004).

INTO THE 21ST CENTURY AT THE COLLEGE LEVEL

As we entered the 21st century more colleges were decreasing or disregarding manual graphics and teaching more computer based graphics CAD. Knowledge was continuously growing and there was burden on faculties to comprise more novel concepts and compress the time permitted for every subject. Manual graphics is slower than computer based graphics CAD so it vanished in several programs. The faculty was presented with a problem - the choice of which software package to adopt based on cost, comfort of use, and education-aiding Computer Design Graphics Journal in 2004 delivered an approach for the collection of software and reiterated that industries were steering to 3D systems (Okudan, 2004). An effective CAD package speeds teaching and the capability of students to create a valuable sketch in a few hours of practice.

Regardless of the importance in several colleges and manufacturing businesses on the choice of computer-aided design software to be used as outfits for engineering design graphics, the true bottom line is the statement of a design – the visuals and graphics (Riddle, 2007).

Another paper presents the progress of a collaborative CAD/CAM system (*COCADCAM*). *COCADCAM* spreads a current single-location CAD/CAM system to a multi-location CAD/CAM application so that two geographically dispersed CAD/CAM users can work together on a three-dimensional CAD-geometry coediting and CAD-related tasks collaboratively and dynamically. Consequently when a multi-location application permits the different users to work together it will enhance the effectiveness and usage of the application and ultimately enhance the graphic designing of engineering product development (Kao, 1998).

Dr. Raul Herrera of The Ohio State University recognizes that the worth of CAD applications in academia and industry is not to be interrogated. His apprehension is that the scholar remains “attentive on exercising their minds to increase their picturing abilities and on applying graphical resolutions to engineering problems” (Herrera, 1998).

Hand-drawn drawing is an ability that is frequently underestimated by scholars who are keen to study the newest “sexy” graphic application. Riddle (2007) considers that hand drawing is a substantial ability in engineering computer design graphics. He states: We have an unhappy deficiency of tools that are of actual aid in the “napkin space” phases of devising ideas. We must take our mind on our thoughts to emphasize on the instrument, and this disturbance significantly obstructs creativeness and early investigation.

A product to discuss this limpidity is being advanced by Riddle. He was not ready to publicize it at this stage of progress; though, he did say: Till alternative instrument is as clear to a person as paper and pencil is obtainable and demonstrates itself in use, hand-drawing abilities will be important. Now this is not to minimize the usage of creative computer graphics (CG) apparatuses, but they have an extended way to go to influence the pencil’s slide. This makes them valuable more for bringing content, relatively than in three-dimensional idea progress and appearance.

Lots of fun with new CAD/CAM systems that will augment dentistry, gives eminent renovations quickly for the products. The development of a selection of novel versions of already available systems as well as altogether new systems will provide expanded capabilities, improved quality, and increasing user friendliness. And new materials will be more visible, apparently coated, and strong enough for full crowns and bridges. The influence of that alteration will only be known in the future. But as the future will reveal, the systems and materials available to us will continue to evolve, improve, and enhance dentistry (Rekow, 1992).

What is being misplaced is the capability to make beneficial freehand drafts wherever and deprived of tools or laptops. The writers have faith in that scholars who are not exposed to hand-drawn drawing do not advance maximum visualization skills - the skill to “see” designs in the mind and interpret them into valuable sketches or describe them to others. For this reason Arizona State University and The Ohio State University still comprise freehand drawing in their commencement of computer graphics courses.

Nowadays, design and design-intent communication requires development. “In the actual world, decent design is not enough - it is the ability to collaborate the design that makes or breaks projects” (Riddle, 2007).

It is vital to note that the values of solid modeling are many. Solid display delivers cool alteration of a design and the ability for examining such as thermal, strength, effects and dimensional checks on associated parts. Once the prototype is shaped, it can be used for practical simulation to discover the design in motion and to increase its look (Clark, 2005). This procedure has been functional to architectural modeling to produce 3D models of projected buildings (Kirton, 2006). Particular universities have delivered amenities for scholars to

create quick samples of their designs and grasp the 3D object in their hands (Barr, 2002).

THE 21ST CENTURY IN THE ENGINEERING PRODUCT DESIGN COMPUTER GRAPHICS INDUSTRY

From the very start of 21st century, like other products the engineering product development industry has also experienced a boost. Although it is hard to categorize the development of this industry in decades, there is strong reason that sudden changes and developments happened in this industry. Therefore, the CAD/CAM technology as well as other new versions of computer graphics applications for engineering product development was introduced and those were very efficient and eminent in the engineering product development lifecycle.

Developments in business practices and technology have affected the engineering product design computer graphics industry. With the global availability of the Internet, Internet-based software's have altered how work is done. The speediness at which data can be transported from one PC to another has similarly made it easy to share engineering product design ideas and computer graphics online on a worldwide level. By means of several softwares obtainable, the preliminary price of application and apprises, as well as complication of these programs are factored into the collection process (Harris and Sadowski, 2001).

One of the challenges of technology invention is that computer graphics applications programs, written by programmers, habitually come with various topographies that the product finds difficult to absorb and consequently turn out to be unfeasible. Availability and interpretation are potentials of a software product, which would upsurge practice.

People progressing from "beginner" to "typical professional" want CAD/CAM packages which are simpler to use. There are already several such packages, mostly developed in the last ten years by the sketch input community (the first annual Euro graphics Workshop on Sketch Input was held in 2004). The author particularly like Sculptris, as people progressing from "typical professional" to "world champion" want CAD/CAM packages which do everything that existing CAD/CAM packages do but also allow enough flexibility for them to express their creative talent (Sculptris, 2013).

These days, hardware improvements as well as evolving technologies in hardware products aim to close charging up with software. Maximum computer graphics softwares are not inadequate by hardware any longer, but for limited element modeling. These restrictions have made us to "entirely focus on the design of our industry's products, and its time of acceptance" (Riddle, 2007). Hand drawing can be discontinued at present due to a portable tablet PC, which every so often comes with 16 h of battery life, is rationally priced, and can store inspired learning stuffs for forthcoming review (Hewlett Packard, 2007). The worth of the digital drawing is the focus of future studies.

Emerging product development by the turn of this century brought about a publicizing of innovative softwares, such as Image-Modeler from REALVIZ. It is a high-end application that creates 3D models from photos or still images of video. In 2000, SensAble Technologies released FreeForm v. 2.0, a haptic modeling application, and I-DEAS 8 software was released for design automation. Most developments in computer graphics applications arise from the gaming industry, so engineering designers should have knowledge of that technology.

Speedy prototyping has moved from just modeling to manufacturing and a fresh article notes work in England on speedy prototyping systems that replicate themselves and create an extensive variety of other products. This might permit under developing countries to create desirable goods in the neighborhood relatively than importing. This idea of machines, which duplicate themselves and create other beneficial stuffs, might be years away but it is a thought that might be understood yet in this century (Thilmany, 2006).

At the moment soft prototyping, which is the procedure of producing a 3D model design that can experience computer analysis, is the emergent technology. It is the greatest noteworthy contribution of computers to the engineering design process. Soft prototyping is quicker and less costly to shape than actual models. It can undertake amendments, and can be used for testing selling.

Graphical plans for construction of machinery and architecture have evolved over the last 6,000 years beginning from hieroglyphics to drawings on printable media, from the "Golden Age" of engineering graphics to the innovation of computer graphics and prototyping. The evolution of engineering design graphics as a profession has also evolved. Years before we entered the 21st century, higher education began to address the changes that technology brought to the curriculum (Harris, 2007).

One more emerging technology is the high-dynamic-range imaging (HDRI) display market. It can "provide an order of magnitude or better improvement in realism and visual information display" (Riddle, 2007). Riddle is collaborating with Arizona State University to establish a computer lab with HDRI technology, video amenities, and other display technologies. Details will be announced within the year.

As per Christine Kelly, Regional Sales Director for CGK & Associates and Developing 3D and Collaborating Imitation Market Adviser, designers these days and in the past have been programmers. Kelly's primary client is EON Reality, Inc (Kelly, 2007).

The client base for engineering product design computer graphics industry players is mounting, and the market is

broadly developing. About 1000 high fortune companies with large/deep pockets are leveraging these gears to improve business practices or even market products. Highly experienced CAD engineers are talented to put on application tools to diverse parts of a corporation to leverage the company's digital possessions. This collaborating product content management (IPCM) is growing to all sizes of businesses (Kelly, 2007).

Subcontracting technology changes our lives, our society, and has a deep influence on our economy. The economic health of the United States is reliant on technologically skilled workers (Harris, 2004). Additionally, how technology has distorted the product engineering design computer graphics industry, and the way that business is conducted has also been altered. The most noticeable modification to present rehearses in the engineering product design computer graphics field is "the dominance of price saving by subcontracting being accepted to excesses, so the bottom line looks good in the short term" (Riddle, 2007). This has led to a lack of technically-competent labors in the United States, particularly computer software engineers.

The brain drain occurrence of subcontracting has political and economic inferences. Riddle (2007) has faith in that "the existing surplus of depositor cash appears to be all in the wrong hands for our nationwide best concern." In the past, colleges have played a major role in talking this subject: "Colleges have always been on the front lines of this war, but this has seldom been properly recognized or funded" (Riddle, 2007).

To resolve more compound engineering problems and achieve larger-scale concerted engineering, the weaknesses to applied application and expansion of Networked Manufacturing (NM) were examined. Technologies, such as cloud security, cloud computing, and high performance computing characterized the computer aided design world (Zhang, 2010).

To further emphasize analysis design, priceless knowledge and direction in contemporary fabrication methods and practices has helped develop compact and low-cost design resolutions and mechanisms such as loose and hybrids, tight couplers, filters and transformers (Mongia, 2009).

An exceptionally big number of engineering and scientific arenas are challenged with the need for computer reproductions to study complex, real world phenomena or resolve stimulating design problems. Nevertheless, owing to the computational cost of these extraordinary loyalty imitations, the use of kernel methods, neural networks, and other surrogate modeling methods have become crucial (Goriseen, 2010).

The computer integrated manufacturing resolves the computer designing of industrial products more by performing the experiments and giving the idea of integrated manufacturing. By adopting this technique industries were able to create integrated products which actually require less space and huge data storage spaces. Further data centers were created by using this technique and utilizing these practices (Rehg, 2012).

The planning and designing of an industrial product not only plays a vital role of creating and manufacturing products but also have to deal with the malfunctioning of the industrial products. Moreover, there are ways through which we can design such products by using the computer based application which brings more effectiveness in the performance of industrial product (Sule, 2009). When we concentrate on the impact of industrial design products on corporate financial performance, we found very few studies have attempted to quantify the contribution that design brings to company financial performance. Hertenstein (2005) inspects the association among industrial design and company financial performance in order to measure industrial design's influence to this enactment. By means of traditional financial ratios, senior managers contemplate important performance procedures; those firms with extraordinary design effectiveness were imagined to have higher revenues, returns on assets, net income, and growth rates of sales, and cash flow than firms with low design effectiveness. This examination discloses that companies rated as having "good" design were stronger on all methods except growth rate measures. These results provide strong indication that good industrial design is connected to stock market performance and corporate financial performance even after seeing expenses on industrial design. Additionally, the designs of financial performance over the seven-year horizon propose that these effects are persistent.

In today's world computer graphics are graphics created using computers and the representation of image data by a computer specifically with help from specialized graphic hardware and software. The interaction, understanding and product development through computers and interpretation of data has been made easier because of computer graphics. Fast Creation of 3D Content is likely to be a big growth area in the next decade or so. Since "Avatar", film companies in various nations have been interested. The paper makes a brief mention of its first appearance (in the late 1990s) but does not follow later developments.

CONCLUSION

We have seen unlimited variations through outlining the voyage of engineering product design computer graphics and the influence it has had on the industry and academe. Design has become a worldwide exertion as the Internet opens up prospects in far diverse time zones for graphic designers to work together on projects. This has caused incompetent workflow with engineering plans being accomplished in half or one-third of the time requisite.

As we move onward in the scientific revolutions of

engineering graphics, it is significant not to overlook the introductory ability of freehand drawing. Academe and the Industry must also work together in a well thought-out manner to recover association and software reform for uncomplicatedness of use if we are to produce inspired and technically competent engineering product designers in the future.

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