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The Importance, Demand, and Absence of Training in Visual Design in Computer Science Programs

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Abstract

Purpose | This study aspires to highlight the significance of the aesthetics or the visual design of digital artifacts, demand for adequate training in visual design by computer science tutors and students alike, as well as the absence of same in the present computer science curricula. Methodology | The study reviewed comprehensive research literature on the significance and implications of good aesthetics of digital artifacts, enquired into its current demand amongst the tutors and students of computer science, and also explored the acknowledgement, and inclusion of any training in visual design in the present undergraduate computer science programs curricula. Findings | The study found historical research evidence in support of the significance and benefits of good visual design of digital artifacts, a very high current demand for adequate training in visual design by tutors and students of computer science, and a very limited inclusion of any training in visual design in the current curricula. Novelty | This study covers three critical perspectives on the topic with comprehensive literature review and two primary studies; and delivers a strong case for adequate training in visual design for all students of computer science. Implications | The study aspires to inspire formal and substantial acknowledgement and inclusion of adequate training in visual design for the undergraduate computer science students, that can equip them with the design skills to develop digital artifacts that are both technically functional as well as aesthetically pleasing.

Introduction

One Digital technology, digital devices, & digital artifacts, such as websites, web apps, or smartphone apps, are now ubiquitous, inextricable, and indispensable in our daily lives, inspiring and assisting us to aspire and complete from our most mundane to the most creative and ambitious tasks. With over 48% (www.statista.com) of the world population now using smartphones, and over 40% of them (internetlivestats, n.d.) now with internet access, the users today have unprecedented digital power in their hands that they; even with no knowledge or comprehension of how it technically runs; seamlessly and intuitively use to complete official duties, indulge in entertainment, design creative artifacts, while socializing and networking round the clock. It is indeed interesting and intriguing to note how so many of these users of digital technology, from across the world with infinite backgrounds, illiterate in many cases, and with no zest or training in digital technology in most; can still keep, maintain and use it very efficiently and efficiently. One potential explanation for this effective mass comprehension and efficient use of digital technology may be the “visual design” of today’s digital artifacts, that the users interact and work with on a device. Today’s digital technology has evolved from a mere device to “compute” to an infinite tool of digital possibilities that are created, delivered, received, understood, and experienced on the screens of digital devices; and much of that is achieved through their effective and high-quality interfaces or visual design.

Today's web is as much, if not more, about visual design and overall user experience, as it is about backend code. Interestingly, our society and culture in general, and Human-Computer Interface (HCI) guidelines in specific, have traditionally discouraged valuing and prioritizing beauty, and hence, the significance and ramifications of good aesthetics or the visual design of digital artifacts have been under debate forever. Digital technology has, and continues to evolve into our way of work, leisure, and life on this planet, as an indispensable partner in our everyday professional and personal activities. Equally apparent is the fact that most of its users today, uneducated in many cases, operate and use websites, apps, and software "visually" through point-and-click or touch interfaces, underpinning the significance and implications of efficient and effective visual design.

This study is an attempt to explore and present substantial prominent research on the importance, explore the need, and need for training in visual design for the students of computer science; as well as review recommendations, investigate current curriculum, and highlight the absence of the same.

Research Hypothesis

1. Well designed, and visually appealing user interfaces may have a positive correlation with, and play an important role in the success of digital artifacts such as websites, softwares, and smartphone apps.
2. There could be a growing acknowledgement and demand amongst today's computer science students for adequate training in visual design in their programs.
3. There appears to be very limited acknowledgement and inclusion of any training in visual design amongst the current undergraduate computer science programs.

Research Objectives

The research objectives of this study are

1. To investigate and assemble comprehensive research literature on the significance and implications of beauty, aesthetics, or visual design in general; as well as digital technology.
2. To enquire with a sample of university students and tutors of computer science, into the value and demand for visual design in their program.
3. To explore, in a sample of international undergraduate computer science curricula, the presence of any course in visual design.

Research Questions

The study leads with the following questions:

1. Does the visual design of perfectly working digital artifacts, such as websites, apps, or software, even matter?
2. What is the existing research, and what does it point to, on the significance and ramifications of the good visual design of digital artifacts?
3. What value do today's computer science students attach to training in visual design for their careers ahead?
4. What is the latest course combination currently being offered under the UG CS programs under the leading national and international universities?

5. Are there any courses in visual design offered to undergraduate students of computer science?

Importance of Visual Design in Computer Science

Beauty or aesthetics, and their role in human experiences and behavior has been an extensively researched topic for decades. The human eye can see 6 million colors in varying details depending on the task at hand (Kosslyn, 2005), and more than half of the human brain's cortex is directly or indirectly involved in visual processing (Snowden et al., 2012), whereas the auditory processing uses only around 10 percent. Aesthetics was listed as a basic human need by Maslow (1954) in the hierarchy of needs and the theory of human motivation. Marcus Vitruvius Pollio (1st century BC) was a Roman architect, engineer, and author; who published the multi-volume work De Architectura, where he argued that all buildings must inculcate the following three attributes: firmitas (strength), utilitas (utility), and venustas (beauty) (Kruft 1994), where firmitas refers to the firmness and stability, utilitas to the utility and usability, and venustas refers to the beauty and visual appeal. All of these fundamental attributes have since been skeletal to all designs including automobiles, furniture, fashion, etc., in varying proportions. George Santayana (1904) proposed three attributes to the idea of beauty. Firstly, beauty is a positive entity that produces positive emotions and reactions in the perceiver on interaction. Secondly, beauty is explicitly intrinsic, meaning objects are either beautiful or not, in their own right, instigating instant observation and reaction, and are not perceived as beautiful with logic and rationality. Thirdly that beauty has to manifest in visible form for someone to perceive it and experience positive emotions. According to Csikszentmihalyi and Robinson (1990), mankind has constantly aspired to create artifacts of beauty, and taken pleasure in them. Lavie and Tractinsky (2004) state that "the word beauty is commonly applied to things that are pleasing, either to the senses, to the imagination, or to our understanding". Modern social science has well established the value and consequences of aesthetics in everyday life. A person's physical appearance (Dion et al., 1972) consciously and subconsciously affects his/her social interaction., and physically attractive people are more likely to be more successful and desirable. Mills & Aronson (1965) found that attractive girls were more effective at persuading males as compared to unattractive ones, whereas good-looking people were found to earn more (Hamermesh et al., 1993), and better-looking teachers received higher evaluations (Hamermesh et al., 2005).

Visual design, according to Zettl (2013) is the process of the most appropriate application of visual elements and techniques, to achieve the most effective and appealing appearance and presentation of the content and the message. Klett (2002) states that "visualization concerns the visual representation of data, objects, and systems in order to enhance communication and thus understanding." Visual design is defined by Interaction-design.org as the deliberate design and development of artifacts that combine visual elements such as imagery, graphics, and typography, as well as visual principles such as hierarchy, space, and layout, with the primary purpose of increasing a product's usefulness and enhancing the user experience. Visual design thus can be understood as the creative technique that develops highly usable and visually appealing user interfaces (UI), supporting the most effective and efficient user interaction (UI), and enhances and delivers the best user experience (UX) possible. It is a well thought of and iterated visual compilation and presentation of a set of information and visual assets, that may or may not require the users to interact with. Zettl (1999) also differentiates between the traditional aesthetics and visual design, where the traditional aesthetics may or may not have a functional dimension, whereas visual design by definition has. Garrett (2002) carved an elaborately detailed model of a complete and effective

user experience into individual factors, The Five Planes, as layers of relevant content and the overall process itself. The process begins at the bottom-most plane by identifying user needs and follows upwards through the scope, structure, layout planes, and finally with the visual design right at the top.

The early research and development in HCI almost completely focussed on the working, functionality, usability, and stability of systems; addressing (Tractinsky & Hassenzahl, 2005) only the first 2 Vitruvian principles of firmitas and utilitas, while ignoring the last principle of venustas. It must be noted that the ISO (2018) defines usability as "the extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency, and satisfaction in a specified context of use"; whereas Nielsen (1993) defines usability of computer systems in terms of five attributes: learnability, efficiency, memorability, errors, and satisfaction.

Research on the aesthetics or the visual appeal of digital artifacts can be traced back to Gait (1985) who asserted that well-crafted and visually appealing interfaces can promote users' interest and enhance the overall efficacy of the system. Kurosu & Kashimura (1995) brought visual design, aesthetics, and visual appeal of digital artifacts to center stage, with their systematic and prototypical study exploring the relationship between aesthetics and perceived usability through 26 ATM interface variations, and finding a strong correlation therein, triggering substantial interest, discussion, and research ever since. Alben (1996) recommended good visual aesthetics as fundamental to effective HCI and overall user experience. According to Gelernter (1998), "consumers invariably go for beauty in the end; ..beauty is the most important quality that exists in the computer world when all is said and done." Anders (1999) asserted that content is indeed the king, but only if it is presented in an orderly, attractive, and if possible, creative manner. In an attempt to compare users' perception and preference between digital artifacts developed by a programmer and a designer, Burmester et al. (2000) found that users consistently preferred and rated the artifact developed by the designer higher on the scales of impression, apparent usability, and superiority. Tractinsky et al. (2000) went a step further, cross-examining the correlation between aesthetics and apparent usability as well as actual usability in the pre-use and post-use conditions, and found one therein as well, declaring "what is beautiful is usable". Shenkman (2000) investigated the predominant source of users' first impression on a website and found "beauty" as the ruling factor of their judgment. Hallnäs & Redström (2002) too argued how, as the original task specific computers transcend and proliferate every aspect of the human life, their concept, execution, and appraisal must evolve too from purely functional to a meaningful and expressive presence, adding that digital artifacts now are the "..bearers of expressions rather than functions". Norman (2002) explains how visually appealing and pleasing products trigger a positive first impression (visceral), and a pleasing and happy state of mind in the users, which subconsciously underpins the subsequent engagement, perceived usability, decisions to strive or quit, and the overall judgment. This phenomenon is referred to as the "aesthetic-usability effect", which addresses the users' propensity to think of better-looking products as easier to use as well as more usable. Wathan and Burkell (2002) showed the participants the same content with varying visual treatments and found that better visual designs were judged as more credible. Hoffmann and Krauss (2004) advocate these studies to be significant and substantial enough for anyone to acknowledge the relevance, significance, and implications of visual aesthetics of any effective and efficient digital artifact such as a website, where the elements of content, usability, and aesthetics must work together for a great user experience.

Tractinsky (2005) passionately reasons and advocates the importance of beauty or aesthetics or visual appeal in all digital artifacts or human-technology interactions saying,

"..aesthetics should be conceived as an integral part of information technology (IT) just as it is in other aspects of our lives". According to Jordan (2000); functionality, usability, and pleasure are the 3 levels of users' needs with digital artifacts, similar to Maslow's hierarchy of needs (Maslow, 1943), where each of the lower levels must be satisfied for the next to be desirable. Dieter Rams' popular and well-received Ten Principles of Design lists "Good design is aesthetic" at the 3rd position, soon after recommending every design to be innovative and useful. Apple also lists "aesthetic integrity" at the top of its design principles for iOS. Lingaard et al. (2006) not only found "visual appeal" to be cardinal to a website's quick and favorable impression but also that reliable and lasting impressions are created within 50 milliseconds of exposure, warning web developers that they have only "50 milliseconds to create an impression". A large number of studies have investigated and found a correlation between aesthetics or visual design and several other non-instrumental or subjective aspects such as improved performance (Moshagen et al., 2009), website content evaluation (Aladwani and Palvia,2002; Sutcliffe and de Angeli, 2005; Thielsch, 2008; De Angeli et al., 2006), perceived credibility (Fogg et al., 2003), satisfaction (Lindgaard and Dudek, 2003, Cyr et al., 2008), preference (Schenkman & Jönsson, 2000; Tarasewich et al., 2001; Cober et al., 2008), urge to buy impulsively (Parboteeah et al., 2009; Chang and Chen, 2009), intention to revisit (Mundorf et al., 1993; Mahlke, 2002; Yoo & Donthu, 2001), fun joy and pleasure (Mathwick et al., 2001; Jordan, 1998), and increased ease and effectiveness of learning (Aspillaga, 1991; Grabinger, 1993; Pomales-Garcia et al., 2005; Szabo and Kanuka, 1999).

Jorge (2013) has stated that the visual aesthetics of digital artifacts profoundly affect the way users comprehend information, make judgments on their usability and reliability, and eventually value their experience with these digital artifacts. Liu et al. (2016) investigated the role of website design on users ' perceived credibility through several versions of a banking website with identical content but different aesthetic treatments and found that the website with a more appealing visual design was also perceived as more credible. Peng et al. (2017) too found that users perceive visually appealing websites as more useful, and this positive experience leads to an overall positive attitude towards these websites. Alharoon and Gillan (2020) on the other hand did not find any significant correlation between website aesthetics and usability, though the study clearly concluded that users unmistakably recognize, compare, admire, and rate good aesthetics appropriately. Ramezani Nia and Shokouhyar (2020) found that website aesthetics has a significant influence on users' "perceived quality of online services," "trust," "satisfaction" and "arousal". In a very recent study, Rouzbahani et al. (2021) found that the websites with a good balance between visual unity and variety were ranked highest on the aesthetics scale.

Demand of Visual Design in Computer Science

Despite the fact that the benefits of good aesthetics or visual design are well established and accepted in academia with extensive and continuing research in the direction (Robert, 1995; Jerry, 1997), there is very limited research and voice in support of, and demand for training in visual design for today's computer science students and tomorrow's computer science professionals, who are expected to contribute and deliver to the ever-increasing demand for computer science professionals. According to Hagerty (1995), as the use of technology spreads, graphics become an increasingly important form of communication. He also expressed worries about how the creators of the technological platforms work and attempt to interact with people in a "language" that is foreign to them because they have little or no background in design aesthetic as a structured language.

Lester (1995) suggests that in light of the progressively visual culture, visual literacy instruction should be taken into consideration in general education. Jerry (1997) discovered that visual literacy is "extremely significant" for both the fine arts & media, as well as engineering students in his research at Brigham Young University. As technology becomes more visual with interactive solutions, it is crucial for computer science students to have the ability to design successful visual interfaces, claims Carter (2003). His work includes a brief overview of the elements and principles of visual design for CS students in the context of technological advancements, but it does not serve as a detailed blueprint for an entire course in visual design that includes information on specific lectures, assignments, and assessments. According to Finnegan and Griffin (2000), current curricula "don't really allow for the necessary exposure to visual design that their students absolutely need." The authors criticized universities for failing to keep up with how the web has transformed how users communicate and interact with information systems. While they have provided a simple four-week model for introducing and integrating visual design into computer science courses, they advise that one or two semesters of instruction in the fundamentals of visual design would be the best course of action, saying that "Exploring visual design principles is essential for today's programmer and for the programmer of the next century.

A traditional undergraduate computer science program covers fundamental programming languages such as C++, C#, Java, Python, HTML, and CSS; as well as applications such as networking, web development, software development, etc. With the galloping research and advances in information technology, human-centered design and user experience design; and some directive with Computing Curricula 2013; a good number of the undergraduate programs seems to have taken note and updated their curriculum with courses such as Machine Learning, Artificial Intelligence, Cyber Security, Experience Design (UX), Human-Computer Interaction (HCI), Creative Problem Solving and IoT. While these curricula continue to explore, and grow in the direction of “technical”, with some engagement with “human-centered design” skills; there is no or very little acknowledgment of aesthetics or visual design in digital products.

The ACM/IEEE Computer Science Curricula 2013 addresses and encourages preparing computer science students to be able to work across several disciplines; listing Human - Computer Interaction at the 6th position under The Body of Knowledge (2013, p. 89) that allows it a total of 8 core credit hours; 4 tier1 hours for Foundations, and additional 4 tier2 hours for Designing Interaction. Here, while the tier1 hours target training in human - centered research - based approach with an appreciation for design thinking process; it is the other tier2 hours that at least address “visual design”, though rather conservatively. It is also worth noting that for several universities who have shared their curriculum for HCI in the document, such as the University of York; visual design is listed as a topic under their HCI - related modules.

Study 1 | Computer Science Tutors and Students

After reviewing substantial research and literature in exploring and validating the importance of visual design the success of digital solutions, as well as demanding a course in visual design in the CS programs; a study was conducted with a sample of UG CS tutors (n=22) and students (n=83) to investigate into their opinion on the same. A short online survey was designed, and shared through a personal network to CS tutors and students, and responses were collected and analyzed.

Table 6.1: *Tutors of Computer Science (n=22)*

"Most of the undergraduate programs in Computer Science do not offer any dedicated or integrated course in Visual Design."			"While technically very competent; no training in Visual Design leaves most of the Computer Science graduates struggling to develop visually appealing and attractive digital solutions, such as a website."		
Disagree	Not Sure	Agree	Disagree	Not Sure	Agree
4.5%	4.5%	90.9%	4.5%	18.2%	77.3%
How important do you think training in Visual Design is for the UG students of Computer Science, on a scale of 1-10?			"There should be a core/elective course in Visual Design in all UG Computer Science programs, to breed adequate "visual design talent" in the CS graduates, in addition to robust technical skills."		
Average Rating			Disagree	Not Sure	Agree
7.4			0%	13.6%	86.4%

Few notable comments in the survey by the tutors in Computer Science:

- "Without an understanding of visual design, students will fail to make fully usable products. Technical knowledge is only one half of the challenge."
- "Not all CS students will need visual design skills in the end, but of course it could open doors if they have such skills."
- "Totally agree that students should also have a design class or training so they won't struggle with designing things."
- "Human Computer interaction is incomplete without proper design tools."
- "Visual UG is very important for the students for graphical aesthetic sense and should be compulsory in the universities especially at graduate and postgraduate levels of computer science students and the computing departments should design these courses for the students."

- "I agree that applied computing programmes should include some understanding of visual design (and importantly HCI/interaction design), however more theoretical or high-engineering programmes likely will struggle to find the appropriate space in the curriculum to do so. Visual design is perhaps less critical of a concern for such programmes."

Table 6.2: *Students of Computer Science (n=83)*

"Visual Design skills are also important, along with coding/other technical skills."			"I think students of Computer Science should have good Visual Design skills as well."		
Disagree	Not Sure	Agree	Disagree	Not Sure	Agree
4%	6%	90%	4%	13%	83%
"I think good Visual Design skills can substantially increase professional opportunities in the IT industry."			"I look forward to having adequate training in Visual Design in my program."		
Disagree	Not Sure	Agree	Disagree	Not Sure	Agree
2%	6%	91%	1%	11%	88%

Few notable comments in the survey by the students in Computer Science:

- "Training in designing digital artifacts is so important. Not everybody's good at design."
- Students who are good at design are lucky cause they'll still do good even if they don't

get proper design lessons. But still, everyone should be taught how to do it properly."

- "Training in visual design is critical to properly design a website, or an app, the do's and don'ts, what looks good and what doesn't. No training in visual design is like sending soldiers to a battle field without any proper training on how to fight and win the battle."

The above study found equivocal support and demand for visual design skills and a course in visual design in a computer science program from both the tutors and the students alike. One notable comment from a tutor was on the inherent priority of the computer science programs for programming/engineering courses, leaving little or no space for visual design. However, one notable comment from a student was an analogy between untrained graduates and unprepared soldiers, left in the field (industry) to fight a battle (of their career). Comments from the tutors too highlighted the importance and value of adequate visual design skills amongst the computer science students.

Absence of Visual Design in Computer Science Programs

Importance of visual design in digital technology, and hence its demand in the computer science programs is clearly not an irrational or new idea; with a long history of extensive research in this direction by researchers, as well as substantial recommendation by the curriculum authority (CSC 2013). However, in a recent analysis of 82 undergraduate Computer Science curricula at leading universities, Kapros (2018) found that only 18% of them offer core modules in HCI, following the ACM/IEEE CS 2013 recommendation on including HCI under the compulsory Tier1 group. 51% of them offer HCI modules only as electives. Kapros has raised concerns that while almost 82% of the CS curricula at the world's leading universities are yet to acknowledge ACM/IEEE recommendation on HCI and actively engage CS students at it; almost 29% of them are yet to offer even basic training in HCI. The fact that a substantial percentage of international universities are yet to acknowledge, accept and implement the recommendations on human - computer interaction by the ACM/IEEE Computer Science Curricula 2013, is a clear sign of a large gap between what is recommended/expected, and what is currently being delivered on ground under the undergraduate computer science programs. Besides, bodies such as the ACM and IEEE must upgrade their acknowledgement and recommendations for human - computer interaction, and especially visual design, to support computer science students develop more human - centered, visually appealing, and useful solutions. MacDonald & Sosebee (2018) reviewed the curricula for dedicated UG programs in HCI/UX for 24 North American universities, and raised concern that although substantial research offers convincing evidence of the significance of visual design in influencing users' experience with digital artifacts; there has not been much research on including visual design, with topics such as "graphic design" or "visual communication" even in the existing HCI or UX curriculum.

Study 2

A study was conducted for this research, exploring and reviewing the course content of the UG BSc programs in Computer Science/Information Technology, offered at the national and international universities operating in the United Arab Emirates from around the world; and checking which ones include a course in visual design. The study shortlisted a set of universities, offering local and international curricula for undergraduate programs. The webpages for the UG programs in Computer Science/Information Technology for each of the universities were reviewed, and all courses offered over the 3-4 years duration were listed. Finally, the course structures were examined for any course in visual design. The study did not

include courses under the specialization pathways, and also considered only the core or compulsory course.

The Edarabia lists 32 universities across all the 7 Emirates offering BSc programs in Computer Science/Information Technology, under national and international curricula. 25 universities out of the 32 listed were selected on the basis of the availability of information on course structure on university websites.

Table 7.1: *The 25 universities shortlisted for the study, offering local and international curriculum were:*

United Kingdom	Australia	UAE	America	India	Canada
9	3	8	3	1	1

Table 7.2: *Universities curriculum:*

ANY course/module/subject in Human Computer Interaction or Experience Design	NO course/module/subject in Human Computer Interaction or Experience Design	ANY course/module/subject in Interface Design or Visual Design
11 | 44%	11 | 44%	3 | 12%

The study found only 44% of the university curriculums to have a core course in experience or interaction design. Interestingly, the descriptions of the other 3 courses found under the "interface" category also only referred to the "human centered design" and "usability guidelines". The study did not find a single course dedicated to developing core visual design skills, independent of the design process or usability guidelines; with a description including topics such as "elements of design", "principles of design", or "visual composition".

Discussion

This study found that an aspiration and consideration for designing effective as well as aesthetically appealing screen layouts, and introducing some training in visual design to this effect for the students of computer science, is neither absurd, nor new after all; as visual design has been one of the established, acknowledged, and advocated elements of every successful design, from Marcus Vitruvius, Dieter Ram, to Don Norman. Clearly a large number of other scholars too have pondered upon the importance, effects, and possible correlation of good aesthetics with function and usability; enquired, and have found empirical evidence of positive implications of beautifully designed and visually appealing interfaces on a range of factors such as first impression (Lingaard et al., 2006), improved performance (Moshagen et al., 2009), satisfaction (Lindgaard and Dudek, 2003), credibility (Fogg et al., 2003), and many more. The 1st hypothesis of the study is strongly supported by an expansive body of research that presents evidence of the importance of well crafted, visually designed, and aesthetically appealing screens, in the success of digital artifacts.

It was also found in the subsequent literature review that, following the substantial acknowledgement and importance of visual design in digital developments, concerns were raised on the absence of adequate training in visual design for the students of computer science, as early as 1995 (Hagerty); following up with numerous other studies (Lester, 1995; Jerry,

1997; Finnegan and Griffin, 2000; Carter, 2003) demanding it. ACM/IEEE Computer Science Curricula 2013 updated itself to include 4 tier2 hours of "recommended" training in "designing interactions" that includes the topic of visual design. A primary study for this research also found over 86% of both tutors and students of computer science either recommending or expecting adequate training in visual design in the program. Also while some tutors considered technical skills as only "half the challenge"; students expressed feeling "unprepared" for the industrial challenges without it. The 2nd hypothesis of this study too appears to be true.

In another primary study, this research found 44% of the international UG university CS program curricula to have no course related to experience design or interaction design. This result aligns well with the recent study by Kapros (2018), where he found 29% of the curricula under study, with no acknowledgement or course of HCI. None of the 25 UG CS curricula under this study included any term or topic of visual design. The 3rd, and final hypothesis of this study also appears to be true.

Conclusion

The ever evolving digital technology, on the ubiquitous digital devices, with infinite digital artifacts such as websites, smartphone apps, softwares, games, and web apps; is now an inseparable part of our lives, where users from infants to oldsters continue to grow, operate, use, and enjoy it efficiently. While these artifacts run on technology, the users operate them visually. This research found expansive and robust support on the importance of visually aesthetic digital artifacts, strong demand for some training in visual design for computer science students, adequate recommendation for the same by the CS Curricula, and yet very limited instances of higher education institutes offering dedicated training for the same. The study concludes a well researched, clear, and increasingly important need for adequate training in visual design for the students of computer science that continues to stay unacknowledged and unmet; and highly recommends sufficient acknowledgement and interventions to introduce adequate training in visual design to all future computer science students, helping them develop increasingly visual, and competitive digital artifacts.

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