Streamlining Augmented and Virtual Experiential Learning in the Industrial Design Education Process

Hasnul Azwan Azizan[1], Zaidi Yusoff[2], Mohd Taufik Zulkefli[3], Fadilla Mohd Yusof[4], Mohd Syazrul Hafizi Husin[5]
{hasnul622@uitm.edu.my[1], zaidi8881@uitm.edu.my[2], taufik905@uitm.edu.my[3], fadila675@uitm.edu.my[4], syazrul529@uitm.edu.my[5]}

UiTM Cawangan Kedah, Malaysia

Abstract. The purpose of this paper is to better understand the benefits of Augmented/Virtual application in Industrial Design learning at higher education institutions. Industrial innovation in emerging technologies such as Virtual Reality(VR), Augmented Reality (AR) three-dimensional printing (3DP) and rapid prototyping pose challenges in design education. Retributing the trend alters the traditional methods of learning the industrial design profession.

Keywords: Virtual Reality, Augment Reality technology,Experential learning,Industrial Design education.

1 Introduction

Through experential learning Industrial Design student will gain a fair assesment on their learning processes depicting the workflow of traditionally informed by iterative cycles of a product, transportation or a furniture-led industry. As the design education sector lagging a bit behind in adopting trend technology and treated it as a novelty, however amidst the pandemic there is a recent spike in communicating virtually where social distancing is largely normalised. With attainable smart devices for educators and student to use, it can now be streamlined more efficiently in the traditional design studio classes. There are a few terminologies could be associated with augmented reality, via mixed or immersive but augmentation has certainly gained its popularity with the social media and gaming platform due to advancement in camera tracking or a virtual 3-dimensional presence. This acceptance should be quick to adapt into the teaching and learning environment especially for the design related areas. Academic design research also could benefit from this type of technology by tracking its maturity and future implementations.

Rapid prototyping and virtual reality, as a result of the advancement of technology, have changed the manufacturing world. Three-dimensional printing (3DP) and virtual reality (VR) or augmented reality (AR) have been made available for individual use around the world, which has an impact on how manufacturing industries and Product Design industries produce designs and manufacture them.

DESIGN-DECODED 2021, August 24-25, Kedah, Malaysia

DOI 10.4108/eai.24-8-2021.2315304

2 Experential Learning in Industrial Design

Experiential learning has been a subtopic in a variety of disciplines, with a strong connection to design education. With a subset in mind, this was elaborated and discussed into four different types of learning styles: accommodating, divergent, assimilating, and convergent. The learning outcomes of industrial design education will be influenced by different learning styles. Various learners can investigate a wide range of observations and develop several ideas. Learning experiences are transformed into vague concepts by integrating students. Converging students assess and refine ideas and theories in order to put them to better use in the real world. In addition, accommodating students participate in hands-on activities. Demirbas and Demirkan point out the relevance of giving students with a chance to exercise different learning styles during designing tasks in a study involving first-year architectural design students. Dunlap et al.(2011) proposed a method for incorporating experiential learning theory into an e-Learning workshop. Design students are obliged to use a multiple divergence–convergence learning environment, as indicated. Many authors stress the significance of aligning learning aids to students' learning styles. Huang et al. constructed an augmented reality (AR)-based learning system towards eco-discovery. However, research that includes learning aids (such as an AR-based system) and learning procedures to improve the effectiveness of experiential learning is lacking. As a result, a variety of theoretical and methodological approaches to engaging student-educator interactions have been tested by a number of academics.

According to Sundaram (2016), the 'Internet of Things' will influence product innovation, connectivity and mobility, and big data analytics. Kalay (2005), agrees on the changes brought by this latest technology revolution by changing the conventional design process into a 'network of design, manufacturing, marketing and management organizations. Conventional product design process requires the designers' involvement through social, cultural, and consumers' research before producing design, thus time-consuming. With the latest revolution in technology of manufacturing, the process can be done within days of sharing information via internet networking around the globe. There are already many companies such as Nest, 3D Hubs, Local Motors and more which produce designs and products for industrial use, makers, and even for consumers use Park (2016). Manufacturing industries, hobbyists, makers, and consumers can communicate with these companies in producing products for market use or personal use.

Technology revolution such as the Rapid Prototyping would definitely changes the means of product design process in industries. Affected by this revolution is also the product design learning in higher institutions. It could change the design process teach in product design learning. One of the affected processes is the Conventional Model Making Process which could be replaced to Rapid Prototyping process such as 3D Printing.

Conventional Model Making Process is a final ideation process in Product Design process. As Isa & Liem (2014), categorized Physical models into four categories; 1. Soft Model, 2. Hard Model, 3. Presentation Model and 4. Prototype. In automotive design, Shahriman, (2012), considers it as aesthetic development and styling. Conventional Model Making Process is the study of form which refers to visual appearance. The complexity of forms can be studied and explored by students in understanding the myriads characters of forms. Based on his findings, Sany (2016), found that conventional model making Process benefits future designers in craft skills (aesthetics and tactile sense), machineries utilization (woodworking and metal machines, and materials understandings), and marketing (costs study and brand study). The understanding of forms is important to future designers as it will give them the advantage of critical thinking while designing.

2.1 Traditional Workflow in Industrial/Auto Design

Phase 0	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Planning	Concept Development	System-Level Design	Detail Design	Testing and Refinement	Production Ramp-Up

Figure 1: Product Design Development Process, Karl T. Ulrich and Steven D. Eppinger

The technique of making physical duplicates of designs at a scale smaller than the actual size of the object is known as physical model-making (Orr, 2008). Scale models have always been an integral part of the curriculum at industrial design colleges. Students utilise models to learn about form and space, to decipher complex designs, to communicate design solutions, and as a presenting tool. Physical models are used to overcome the constraints of two-dimensional (2D) photographs as visualisation aids (Tucci, Bonora 2011). In their undergraduate year, students are taught the fundamentals of model-making and are given the opportunity to build concept models. The skills acquired are applied in the design studios. The model building process in the design studio begins with design sketches; once a design has been completed and drawings (either hand drawn or computer aided) have been prepared, the scale of the model is determined, materials for the model are chosen, and the construction process begins. (1) drawing the model outline onto the material chosen to build the model, (2) cutting out the parts, and (3) fitting the pieces together to create the desired shape are the three basic processes in the construction process. Though model construction is a very successful technique for teaching design ideas, there are a couple of disadvantages to model building, including poor quality, human mistake (Agarwal et al., 2009), time limits, and student apathy.

As real-time 3D scene reconstruction from data sensors has improved over the previous decade, the study of such data in VR/AR contexts has made significant development in its usage for the learning processes. Exponential development of telepresence systems, a projection of oneself into the virtual environment, has emerged from the merging of both components, although it is riddled with substantial technical problems. Nonetheless, its application in the design education sector has always been regarded as a novelty item rather than a widespread adoption. According to design education viewpoints, only a few institutions or enterprises connected with design education could ever use this technology at the same time. In order to meet their standards in teaching and learning, other institutions would crawl in at a slightly slower pace or adapt the touch surface method to these digital courses.

3 Industrial Design Learning Future

While there are plenty of new transdisciplinary academic specialisations springing up, all with the goal of optimising the use of smart technologies for their own particular needs.The rapid growth of smart technologies has resulted in significant job opportunities, but a large percentage of new jobs in the design development of smart products require a combination of skills and knowledge in the areas of design research, user studies, and usercentered design in order to improve the user experience, which is not commonly associated with either the technology-based such as digital media.

As little more than a result, industrial design has a considerable advantage and is ideally positioned to address the challenges of smart technology and products. Industrial design, like many other academic fields, has been shackled to a theoretical model that evolved in reaction to the industrial revolution. Although it has attracted public interest, there is certainly a chance for the profession to reinvent itself as a leader in the design development of new sectors including new waves of interactivity.

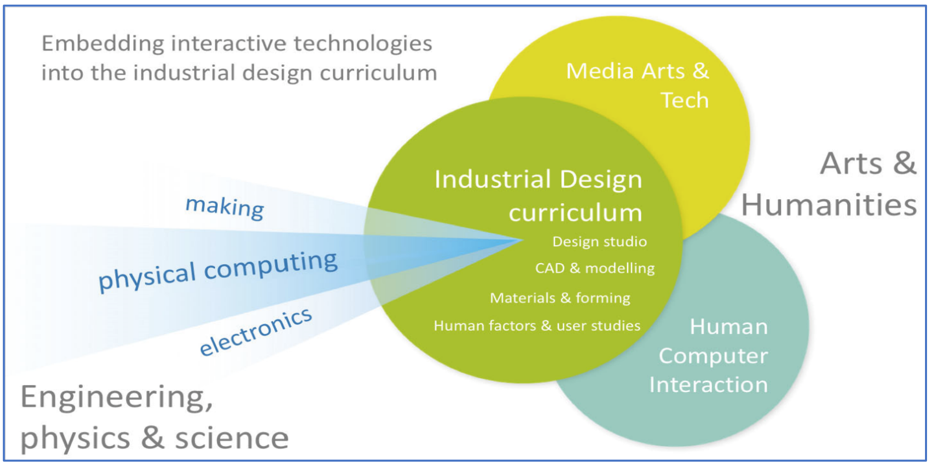

Figure 2: Interactive technologies, user-centred design methodologies, human aspects, and studio teaching are all part of the new curriculum.

Industrial design schools have a significant opportunity to lead the way in the role that interactive technology will play in our daily lives in the future. As businesses and industries recognise the need to more effectively serve the needs of their customers, employees, and other stakeholders involved in their operations, the ID focus on the user engagement and human value is rapidly becoming a highly valued commodity.A new curriculum was created as a template for using the Industrial Design discipline's traditional strengths by combining a strong hands-on understanding of IoT, and coding with a clear focus on the key values of Industrial design premises. Budd, J., & Wang, W. (2017). believed that by pursuing this method, we will be able to gain a competitive advantage and distinguish our students' abilities from those of students in related technical fields.

4 VR & AR in Design Education

In light of design education, with an emphasis on industrial design, Virtual reality, sometimes known as VR, is a new adaptive technology with applications in a range of fields such as health, gaming, psychology, and sociology. The application of virtual reality in education is intriguing and warrants further examination, but research on the subject is currently restricted. This allows for the investigation of new frontiers, one of which is design education. Traditional approaches are still used to teach design education, which is an important element of the curriculum for architecture students who want to conceive problem-solving. Özgen, D. S., Afacan, Y., & Sürer, E. (2021) reintroduce the scarcity of study into VR deployment. The recommended use of virtual reality (VR) in basic design education and emphasises on its usability, especially for problem-solving activities. It goes over the research on digital design education, virtual reality, usability standards, and technological acceptance strategies.

A few related studies looked at the degree of immersion and how it could be used in conjunction with other technologies and tools to create a realistic sensation of presence in a virtual design environment. Virtual reality has progressed to the point where it could enhance users' sensory immersion, allowing for more realistic interaction and experience with a virtual prototype.Others, on the other hand, saw this technology as a supplementary tool that needed to be integrated with physical items and haptic systems in order to provide a satisfactory sense of immersion. Because touch is such a vital factor to consider when it comes to the VE, employing a genuine object as tactile feedback could allow for complete manipulation control in the immersive environment.

There is currently a lack of a complete picture of the benefits of virtual reality in design. In many cases, academics concentrated on specific design functions rather than offering a comprehensive picture. A bigger picture can help us understand how VR supports various design roles and how they can benefit from different levels of immersion and extra tools. As seen in the diagram below, many of the most recent evaluations in the literature that looked at VR technology had a different focus or goal.

5 Differences in Design and Programming Languages

There are several challenges that course instructors or lecturers confront in ensuring the norm or schools of art and design encounter when developing design curriculum. Will therefore programming be taught at all, here for the sake of performance when compared? Whether this is the case, how should it be addressed in the curriculum? What Designers must first clarify what we mean by programming until we can begin to solve these challenges. There is a significant gap between the two disciplines in terms of regulatory output.

Industrial design are normally associated with the creative arts and are viewed from a certain viewpoint from an Industrial Design student. The same principal also should be applied to most of the said academic reserachers as well. The expected usefulness of art and design courses has traditionally been focused on the development of students' understanding in terms of aesthetic and design knowledge, as well as the acquisition of specific skills. Art and design courses have evolved to suit the usage of digital technologies as the effect of new technology has grown Amiri (2011). This usage is commonly utilised at the same time. digital tablets and rendering software in design courses, digital video cameras and video-editing software in video courses, illustration and desktop publishing packages in graphic design courses, 2D and 3D animation software in animation courses, sound and music generation and manipulation software in music courses, and various computer-based design and manufacturing packages in courses such as furniture design and manufacturing.

Although design classes have been open to using various software packages in their curricula, there have been some reservations about their potential negative impact. The main source of concern appears to be that students regard "software skills" as design abilities rather than tools that are used to implement and generate the design, i.e. production tools. Educators must sometimes work hard to ensure that pupils focus on the subject content rather than the instrument, such as software. While practically all art and design schools have had to adjust to the growing role and impact of computer technology, certain courses are entirely dependent on it. Among which are computer games, interactive media/multimedia, and web design. The demand for competent professionals in the design and creation of interactive multimedia artefacts rose in tandem with the market for such individuals. Crawford (2003) describes the field of developing interactive artefacts as "lying at the intersections of information technology and creative practises" or "lying at the crossroads between arts/humanities and science/engineering". As a result, it's unsurprising that courses with similar sounding names are assigned to different academic schools and departments, each of which, understandably, wishes to maintain its own distinct character.

Many computer science courses emphasise on software engineering and programming, with the hope that students would pick up any essential aesthetic and visual design abilities later in the workplace, or that they will acquire a job as a developer on a team that includes expert designers. The majority of courses offered by art and design colleges focus on artistic, creative, and visual design skills, with programming being avoided as much as possible.

5.1 Industrial Design Curriculum Conundrum

As Industrial Design scholars, we are up against a somewhat disruptive phenomenon. In its divergence from traditional design attitudes toward the construction of its courses. The distinction between "design" and "assembly," as well as between "design" modules and "coding" modules, or "trainings," demonstrates this. Similarly, 'design' is normally considered of as a 'creative' and 'intellectual' activity best addressed by 'academics,' whereas 'programming' or 'code' is mostly thought of as a 'technical' and 'mechanical' activity best taught by computer scientist. This separation is arguably a side effect of the confusion that is caused in real life when many people who call themselves designers do things that 'developers' do, and likewise. It's no coincidence, however, that when people try to fit what they do on a daily basis into the labels of 'designer' or 'developer,' they have hard time fitting their activities into just one of those titles and have to inquire, 'Have become we designers or developers?' Johansson (2007). Some have even recommended that the following terminology be invented to reflect the integrated design and development activities, such as 'design per' or 'designers' Fain (2008).

5.2 Basic Programming Language for Industrial Designers

There is a lot to cater for industrial design students when it comes down to a programming language. When it comes to scripting platforms for industrial design students, there is a number of things to consider. They are perhaps used as the end user, but they are not proficient enough in handling with computational vocabulary, which is believed to be outside their normal routine. Although it is regarded as both intricacies of the computing language and obvious difficulties for design students. The contradiction between syntax-based education and design practise is well-known, but the fundamental parallels in how they are interdependent are less well documented. Since design students need to connect with others, explore their new surroundings, and get by, they must learn the language. In industrial design, new ideas on programming and the creation of interactive artefacts that are more in tune with culture and tradition are required. Nevertheless, the resistance to 'Structure' approaches is growing, and new perspectives on nonprogramming, software development, digital design, and the function of code are emerging. It's interesting to note that as we move away from the engineering paradigm, were getting closer to a more 'arts' and 'creative' software creation paradigm.

Research into existing tools and infrastructures in recent years has revealed limits that prohibit communication technology from fully facilitating informal interactions, such as Morrison-Smith, S., and Ruiz, J. (2020) discussed the challenges of a virtual representation, which include the identification of these challenges. As a result, other approaches to promote informal communication in geographically distributed collaborations are required. In this situation, a virtual depiction of a design artefact is an ideal area where the industrial design approach could be beneficial. The use of a webcam in conjunction with a meeting application not only represents the person, but also allows them to communicate their design work in real time. Despite the fact that this technique is not fully documented and has some limitations, it is necessary to take that leap in assure that it will not be ignored in preference of more traditional design sharing activities.

Fig. 3: Augmented reality car prototype created with Unity and Vuforia software and streamed through Google Meet.

5.3 Underlying Strategy and Visual Framework

To better access and select the most appropriate adaptation of (VR) and/or (AR) technology, a clear vision of simplifying the bits of technology introduced in recent years or ahead is required. Little is known about how much research has been done on the varied interpretations of its tumultuous existence in the Industrial Design Literature over the years. As a working strategy for data collecting, a practical approach is introduced into the research.

First, the iterative re-identification of digital tool usage that has occurred in recent years in response to (VR) (AR) technology without diminishing its historical worth. Second, employing workable tabulation and taxonomy of existing output in via (3DP) as a guiding tool for identifying important strategies for simplified (VR) and/or (AR) adoption in Industrial Design education. Because it is most believed to be relative to (VR) and/or (AR) ground, (3DP) tabulation outputs are employed. Fourth, in retrospect of affirmative activity, a visual assistance of established framework is introduced and addressed throughout the substance of this paper.

The following is the sequence in which the underpinning strategy and visual framework are layered

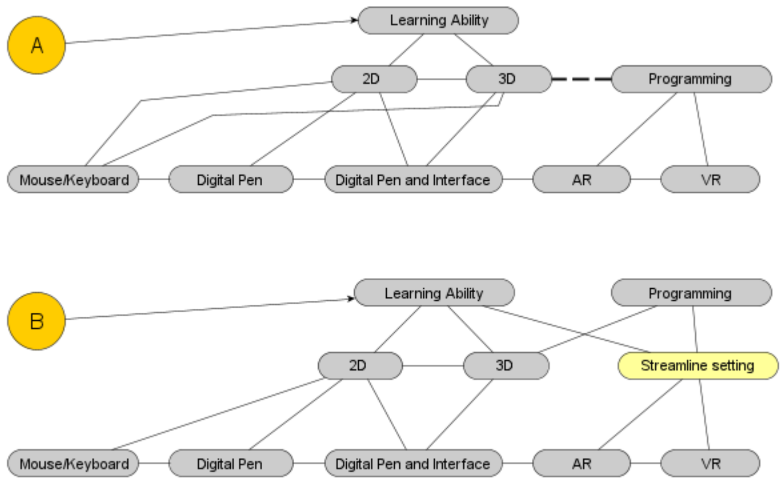

Figure 4: Bloch Model of Progression of usage in digital tools for designers in learning ability, (A) Represents current Meta adaption for VR/AR, (B) Full adaption of the learning cycle

The (A) model cycle is depicted as the breakable connection between coding needs in developing id content and the learner's capacity to comprehend a large programming language in this multiplicity of models presented as nodes above. In contrast, the (B) Model appears to have completed a full circle if the complex programming is supported at the background level and is fronted by a simpler programmable interface. Despite the fact that model (B) is regarded as a steady representation for ID students in adapting the whole circle of technology, it is clear that various VR and AR gadgets have been simplified or targeted for industrial Design education. However, in order to fully utilise AR and VR in design education, a common ground for design education is required to filter out the needs for defining learning curves.

Fig 5. Similar Technology with different attribution.

SKILLS	A	B
Sketching		
2D sketching	✓	✓
2D digital drawing	x	✓
Model Making (scale)		
Conventional model making (foam, fibreglass, wood, etc.)	✓	✓
Rapid prototyping	x	✓
Computer Skills		
CAID (Computer Aided Industrial Design)/ 3DModelling	✓	✓
Auto design surfacing (e.g., Surface A, B or C), CAS	x	✓
Programming	x	✓

Fig 6. Taxonomy of difference between training and gaining skill knowledge.

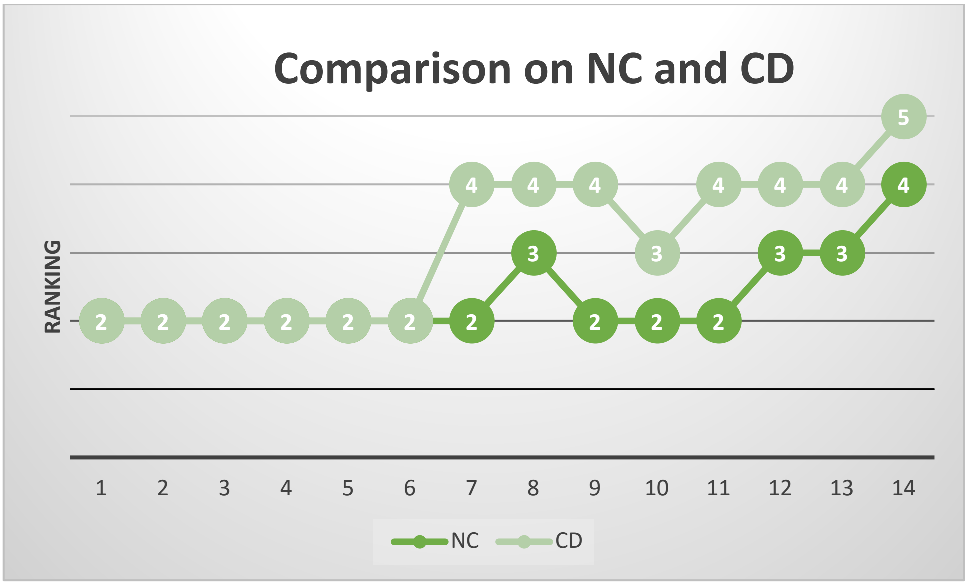

Figure 7: Tracking Model of Digital Tool Usage for Designers as a Function of Learning Ability (A) Represents current VR/AR Meta adaptation, (B) Full learning cycle adaptation.

These examples demonstrated simple physical periods that may be used to check processes and, more importantly, have a substantial impact on model creation and coding for design students. Assessing the timeline for industrial design learning will lead to a better understanding of how to create a reasonable workload for students to advance their programming knowledge without jeopardising the subject's creative and critical design thinking skills.

Conclusion and Recommendation

Conversely, learning and teaching augmented and virtual as an important element of the industrial design process, as well as its value in reassessing future development with concurrent technology, are discussed. It is necessary to identify and assess programming language implementation for the learning process in industrial design education. In principle, this study will build on the sensible approach to incorporating AR/VR into industrial design education and practice.. There is, however, a more upscale method in haptics and tacticle that will be examined for greater research demands if the technology has matured rapidly enough to be simplified and evaluated for the next phase of this research.

In terms of developing a trustworthy understanding of the validity and implementing technology in design-led teaching and learning experiences, a more pragmatic proposal is required. Progressive methods of analysis that are in accordance with industry practices are evaluated and cultivated for future use.

References

[1] Crawford, C. (2003). *Chris Crawford on game design*. Indianapolis, Ind: New Riders.

[2] Kalay, Y. E. (2006). The impact of information technology on design methods, products and practices. *Design Studies*, *27*(3), 357380.https://doi.org/https://doi.org/10.1016/j.destud.2005.11.001.

[3] Johansson, R. (2007) Are we designers or developers? (online) Available from URL: http://www.456bereastreet.com/archive/200708/are_we_designers_or_developers/(accessed 19 April 2020).

[4] Aryana, B., Zafarmand, A.Y. (2007). Glocal product design: A sustainable solution for global Information Technology on Design Methods, Products and Practices. Design Studies, 27 (3), 357-380. doi: 10.1016/j.destud.2005.11.001 companies in regional and/or local markets. In: International Association of Societies of Design Research, IASDR 2007. The Hong Kong Polytechnic University School of Design, Hong Kong

[5] Fain, Y. (2008) Do We Need to Teach Designers Programming? (online) Available from URL: http://flex.sys-con.com/read/524699.htm (accessed 20 April 2020)

[6] Amiri, Faramarz. (2011). Programming as Design: The Role of Programming in Interactive Media Curriculum in Art and Design. International Journal of Art & Design Education. 30. 200 - 210. 10.1111/j.1476-8070.2011.01680. x.

[7] Isa, S. S., & Liem, A. (2014). Classifying Physical Models and Prototypes in the Design Process: A study on the Economical and Usability Impact of Adopting Models and Prototypes in the Design Process. In DS 77: Proceedings of the DESIGN 2014 13th International Design Conference

[8] Kolb DA. (2014) Experiential learning: experience as the source of learning and development, 2nd ed. Experience Based Learning Systems Inc, New Jersey

[9] Sundaram, K. (2016). The Internet of Things and The Changing Landscape of Product Design. Retrieved fromhttp://resource.ansys.com/staticassets/ANSYS/staticassets/resourcelibrary /Article/The-IoT-and-the-Changing-Landscape-of-Product-Design-AA-D-V1-I1.pdf

[10] Park, R. (2016). 30 Most Innovative 3D Printing Companies in 2016. Retrieved from https://all3dp.com/best-3d-printing-companies-startups-to-watch/#3dhubs

[11] Sany, M. (2016). The Practice of Conventional Model Making and Rapid Prototyping in Product Design Education at the School of Arts, Universiti Sains Malaysia. (Master's Thesis)

[12] Budd, J., & Wang, W. (2017). Industrial design education: Taming technology to enhance user experience. *Archives of Design Research*, *30*(3), 17–27. https://doi.org/10.15187/adr.2017.08.30.3.17

[13] Morrison-Smith, S., & Ruiz, J. (2020). Challenges and barriers in virtual teams: a literature review. In *SN Applied Sciences* (Vol. 2, Issue 6). Springer International Publishing. https://doi.org/10.1007/s42452-020-2801-5

[14] Berni, A., & Borgianni, Y. (2020). Applications of Virtual Reality in Engineering and Product Design: Why, What, How, When and Where. *Electronics*, *9*(7), 1064. MDPI AG. Retrieved from http://dx.doi.org/10.3390/electronics9071064