Higher Education 4.0 Technologies: Survey of Immersive, Interactive Content Development and Materials Deployment Within A Developing Nation

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Abstract. Industry 4.0 manufacturing processes are making advanced hardware and the latest software cheaper, and easier to employ for teaching and learning. In the process, the objectives of the Higher Education 4.0 initiative are being realised. Tertiary educators should take heed of these developments so that their undergraduate students could benefit from education technologies that are geared for the current technologically savvy generation. The question that needs to be asked is, are tertiary educators taking advantage of innovative teaching and learning technologies by becoming content developers? And, are they deploying educational materials that align to the principles of Higher Education 4.0 for the advantage of their tertiary students? This empirical paper reports and discusses findings from a survey on content development and materials deployment by Malaysian tertiary educators from different fields across a range of tertiary institutions in Peninsula Malaysia. Results do not look encouraging. Some respondents stated that they do use high-end learning materials in teaching and learning, just not content that they have created on their own. Only a minority are taking advantage of new technological tools to create their proprietary immersive and interactive materials, a finding that might be the case for many developing nations across the globe.

1. Introductory section and opening remarks

Technology has propelled human civilisation further over the past two decades than in the last two hundred years [1], particularly with the advent of the Internet, and Information and Telecommunication Technologies (ICT). At present, with the 4th Industrial Revolution upon us, newer (and cheaper) technologies that enable us to speed up communication as well as facilitate information exchanges are nothing short of incredible. Together with social advancements, technological evolution is directly and indirectly affecting and altering everything from industrial procedures to the process of teaching and learning [2] [3]. Without a shadow of doubt, the adoption and integration of new technologies are keys to advancing the field of education, thus supporting the teaching and learning dyad for 21st century classrooms and beyond. Novel and cutting edge technologies in education are needed for the delivery of instructional contents, for example, to make educational contents more interactive and truly immersive for the current generation of digitally oriented learners [4] [5].

Interactive and immersive instructional contents are required to meet the needs and wants of ‘Generation Z’ (adolescents born between 1995 and 2015) and now ‘Generation Alpha’ (children born between 2011 and into 2025). These generations are the children, teenagers and adolescents born at a
moment of never before seen technological changes, especially those brought by the 4th Industrial Revolution or Industry 4.0 [6]. The members of both Generation Z and Generation Alpha were and will be born into technology, in developing and developed nations all over the globe. Learning by rote will not cut it for members of both generations whose attention spans might seem to be shorter as opposed to previous generations. Yet, they can quickly sift through chunks of information and make sense of knowledge quicker compared to older generations, due to the fact that technology is a part of who they are as they were born in the digital era. This empirical research investigates the use of new technologies related to the Higher Education 4.0 movement that goes hand in hand with developments in Industry 4.0. This research paper examines why and how Malaysian tertiary level educators are developing contents and materials that need to be deployed through cutting edge technologies especially for the benefits of their learners from Generation Z.

2. Review of current literature in the research areas
As Industry 4.0 manufacturing processes are making novel hardware and software cheaper, and easier to use for teaching and learning, the visions of the Higher Education 4.0 initiative are being quickly realized in tertiary education. Tertiary educators should no doubt be taking advantage of these speedy advancements. They need to make sure that their undergraduate students could benefit from educational technologies that are most suitable for the present technologically savvy adolescents. These initiatives will enable tertiary level students to learn in more interactive and immersive ways, and in the process help them to prepare for a disruptive future full of difficult social challenges. This first major section reviews literature that is related to the research topics at hand.

2.1. Higher Education 4.0 technologies for instructing and learning
Post year 2020, novel technologies are being extensively adopted and adapted within the world of tertiary education to enhance teaching and learning processes in many different academic fields [7][8]. At this point in time, it is quite clear that what was useful in the past two decades is no longer useful in the here and now. Using ‘clichéd’ technologies now appear tired, obsolete and just plain old or even lazy [9][10], especially when tertiary educators now have unlimited means to bring innovative practices to their classrooms to teach a variety of academic subjects [11]. Many studies have proven the significance of integrating new technologies into the teaching and learning process. For instance, Microsoft PowerPoint presentations used to play a central part in the sharing of information within university classrooms and lecture halls. In the present day, Microsoft PowerPoint presentations are just too old fashioned as better presentation technologies have emerged within the field of education over the past two decades. Figure 1 illustrates digital or online educational objects from less recent and not too interactive ones to more recent and more immersive objects, adapted from the empirical research by Adnan, Ya Shak, Karim, Tahir and Shah [1].

![Figure 1](image_url)
Massive Online Open Courses (MOOCs) and Blended Learning (BL) are amongst newer technologically-enhanced educational approaches that have been introduced. MOOCs and BL are now being implemented to enhance the educational processes within university classrooms worldwide. It is proven that the integration of both face-to-face (offline) and online materials bring positive implications for learners as they consider this approach to be quite helpful in their day-to-day learning experiences [12]. In Malaysian classrooms, the emergence of this teaching approach can also be witnessed. The MOOCs initiative have begun to be implemented by lecturers from Malaysian tertiary institutions in their classrooms and lecture halls. In year 2020, most Malaysian tertiary institutions would have embraced this recent growth in the realm of education to enrich the process of teaching and learning for the 21st century and beyond [13].

Apart from MOOCs and BL, Higher Education 4.0 technologies put much emphasis on user experience (or UX) in the teaching and learning process and not just user interface (or UI). We take for granted the use of thick and heavy university textbooks from the last two decades, but the use of textbooks is quickly being replaced or augmented (pun intended) with other forms of knowledge ‘containers’ [14], for instance Virtual Reality (VR) and Augmented Reality (AR) teaching and learning materials [15]. VR and AR for classroom teaching and learning will surely revolutionise the ways that teachers teach, and learners learn. Over the years, we have witnessed many innovations in the field of education. That being said, older applications are still being used by some university educators, such as Microsoft PowerPoint. With wider adoption of VR and AR within the realm of tertiary education around the globe, university undergraduates will hopefully be freed from their desktops to learn interactively through immersive experiences that also bring unlimited opportunities for exposure to first-hand knowledge beyond the four walls of the classroom [16] [17].

2.2. Education technologies for exposure, interactivity and immersion

At present, there are many technologies available for university lecturers (who take on roles as content developers and/or learning technologists) that result in better interactivity, higher immersion and longer exposure to knowledge. One such example is 360-degree videos. 360-degree immersive and interactive videos allow learners to dive directly into educational contents in a virtual setting [18]. Even though the concept is really cutting edge, 360-degree videos together with VR technology have become an innovative educational technology beyond niche consumer markets of early adopters. The availability of new gears, including head mounted displays (HMD) that incorporate external cameras and screens that can be directly linked to the user or even simpler HMD-like interface that rely on users’ smartphones, allow the realm of tertiary education to rapidly evolve beyond dry textbooks and boring classroom-based lectures. This educational technology is currently being used in education from the first grade to college level in the United States whereby learners can experience the immersive contents of any academic subjects using VR headsets [19]. In addition, a 360-degree view of any educational content provides learners with a more realistic feeling of being part of the environment.

With the wider use of 360-degree videos, learners can experience complete scenes and can further engage with educational contents [20]. The 360-degree video can be dragged up, down, left and right. Hence, this will provide learners the freedom to roam within a truly immersive experience. In other words, they can decide where and when to look. Video platforms such as YouTube and VeeR now offer 360-degree video streaming, simultaneously enabling lecturers and learners to upload and share contents worldwide [21]. Thus, 360-degree videos offer a unique sense of presence, as opposed to conventional video materials that can never come close to this level of immersiveness. This immersion is due to the significant emotional connections being made between learners and educational contents. For instance, stereoscopic sound makes it easier to link with the content as it directs attention to the ‘story’ unfolding [22]. 360-degree videos are indeed a new way for exploring unique and innovative digital educational materials. Most importantly, positive learning outcomes should be achieved through the deployment of these technologies of teaching and learning [23]. That being said, no matter how wonderful certain innovations are, some flaws can still be identified in VR technology. For instance, VR goggles are quite huge in both size and heft, making it hard for learners to handle them.
for longer periods especially if they are physically small. Furthermore, through the use of VR, dizziness and motion sickness may be experienced by some learners [24].

Quite different from the conceptualisation of VR, Augmented Reality utilises the actual environment around us and then overlays animations or virtual forms of information on it [25]. One of the advantages of developing AR educational materials is that, it does not need a dedicated display device like big and heavy VR goggles. Because of this, the technology should become more mainstream in the near future. AR enables learners, especially younger ones, to visualise the subject matter rather than just reading a chapter from a physical book [26]. It is true that not all academic subjects can be easily taught and learned using AR, but the technology does help learners achieve greater perspectives and insights regarding certain topics. As stated above, one of the selling points of AR is that it does not require any heavy hardware investments. Students can simply use their smartphones or computer tablets to experience AR, for example to observe a 2D picture that turns into a 3D animation. Dino Park AR, available on the Apple App Store, is an example of how learners can be transferred to the prehistoric era, allowing them to experience walking with living and breathing dinosaurs within the classroom. AR without a doubt, can stir the interests of learners and keep them excited about learning.

2.3. Content development and materials deployment, and the roles of tertiary level instructors

The preceding paragraphs critically reviewed the benefits of newer, highly immersive technologies for instructing and learning, especially in higher education. If the tertiary education sector employs and deploys these technologies in actual teaching and learning, university students will gain tremendously [27]. As we know, tertiary education programs are progressively moving to online digital formats because digital sources are easily disseminated to a wider audience, making learning truly open, anytime and anywhere [28]. Owing to this fact, tertiary educators (lecturers) need to be one step ahead of everyone else in adopting and adapting these technologies. They must be at the frontline to move tertiary education from traditional teaching techniques to more technology-friendly experiences in, and even out of, the classroom.

Tertiary institutions have now acknowledged the need to improve classroom experiences to make diploma, degree and taught master’s courses even more enjoyable, and deliver immersive educational experiences [29]. It is no surprise that virtual worlds with computer constructed recreations of objects and events that occur in the physical world are currently the ‘in’ thing at all levels of education [30]. The power to generate alternate environments is making virtual worlds beneficial for undergoing hazardous science and medical experiments or facing logistically impractical simulations that tertiary learners would have trouble seeing in front of their eyes and experiencing emotionally. The critical question now is, are tertiary educators ready to take on the role of content developers for such cutting edge teaching and learning technologies? There will be difficulties, as this empirical study will show. But, it is also through great difficulties that humans have made it to the stars.

3. Methods and procedures of the survey research

This empirical research paper reports and discusses findings from an online survey of trends on actual content development and materials deployment by Malaysian tertiary educators, from different fields of expertise across a number of tertiary education institutions in Peninsula Malaysia. Several steps were taken to control the data and raise the validity and reliability of survey items. First, only content development and materials deployment based on newer, highly immersive educational materials are examined, as depicted in Figure 2. Second, the respondents chosen were, in the main, science and technology lecturers together with a small number of technical and vocational tertiary educators. Third, the survey was developed based on a number of published studies on this same topic and piloted beforehand with a handful of peers. To operationalise the discussions in previous paragraphs and to address the concerns of this research project, two research questions guided this empirical effort, as outlined below.
First, are Malaysian tertiary educators taking advantage of presently available teaching and learning technologies by becoming content developers in their own institutions? Second, are Malaysian tertiary educators deploying relevant educational materials that align to the principles of Higher Education 4.0 to the advantage of their tertiary level students?

Data were collected in December 2019 to January 2020 through an online survey form that contains 27 items, not including demographic questions. The central focus of the online survey is on the development and deployment of: (a) 360-degree immersive videos, (b) virtual learning environments (VR), and (c) augmented reality materials (AR).

Altogether, 169 respondents (n = 169) completed the survey and provided useable and useful data as presented in the next section. Out of the total number of respondents, 118 or 69.82% were male lecturers and another 51 or 30.18% were female lecturers. They represent different science and technology faculties or departments for example applied sciences, computer sciences, pure sciences and engineering. A small number of the respondents (24 respondents or 14.20%) are technical and vocational lecturers who teach skills-based subjects like masonry, plumbing, welding and wiring. All of the respondents are from the west coast of Peninsula Malaysia and they hail from three universities and two polytechnics. The youngest respondents were 26 years of age whilst the oldest were 41; all of the survey respondents indicated that they possess postgraduate training of some sort, apart from their first degrees or advanced diplomas in their areas of expertise. All other demographic details are considered not relevant to this study’s research questions and will not be disclosed. The link for the online survey was sent to our personal contacts in the research sites, those contacts in turn passed the link to their colleagues who had time and space to fill out the online survey form. Prominent findings from the online survey are presented, next.

4. Data from the survey research
In this section, first-hand data from the research are presented. The data collected were analysed using simple statistics looking at mean, mode and median occurrences. The data analysis was carried out to examine the pervasiveness of two critical activities by Malaysian tertiary level educators. First, the development of educational contents in the form of 360-degree immersive videos, contents that incorporate virtual learning environments (VR) and contents that integrate augmented reality materials (AR). And second, the deployment and distribution of novel educational contents in the shape of 360-degree immersive videos, contents that incorporate virtual learning environments (VR) and contents that integrate augmented reality materials (AR). Survey items were distributed equally between the three types of newer, highly immersive digital learning contents (i.e., 360-degree videos, VR environments and also AR materials). Each survey item is an ‘I-statement’ type as will be shown
below, and responses were collected based on either a simple ‘No’ versus ‘Yes’ choice or a 6-cline Likert scale from ‘Strongly Disagree’ at the leftmost position to ‘Strongly Agree’ at the rightmost position.

Tables 1, 2 and 3 below show responses to survey items number 1, 10 and 19. These items are critical because they seek answers to whether or not the 169 survey respondents actually developed educational materials or contents that are built upon Higher Education 4.0 learning technologies. As applied sciences, computer sciences, pure sciences, engineering, and technical and vocational lecturers, they should not just reuse educational contents, but they should be developing new contents using 360-degree videos, VR environments and AR materials for the benefit of their students. The data nevertheless are not encouraging, as seen in the tables below.

**Table 1.** “I created contents using 360-degree videos for subject(s) I teach, in the last 12 months”

| No | Yes |
|----|-----|
| 147 (86.98%) | 22 (13.02%) |

**Table 2.** “I created contents employing VR environments for subject(s) I teach, in the last 12 months”

| No | Yes |
|----|-----|
| 149 (88.17%) | 20 (11.83%) |

**Table 3.** “I created contents employing AR materials for subject(s) I teach, in the last 12 months”

| No | Yes |
|----|-----|
| 138 (81.66%) | 31 (18.34%) |

Within the current tertiary education climate in Malaysia, these findings are not too surprising. Furthermore, just because these educators did not develop their own educational contents that used or employed 360-degree videos, VR environments and AR materials, the findings do not necessarily mean that they shunned these Higher Education 4.0 technologies outright. In fact, a small number have communicated (via private channels not related to the survey) that they do use such technologies in the subjects that they teach, just that they do not have the time, financial resources or technical expertise to develop such high-end educational contents on their own.

Given that there was very low content development for the three types of technology, the deployment of said contents (i.e., 360-degree videos, VR environments and AR materials) by the survey respondents was correspondingly low and the frequency is quite similar to the findings in Tables 1 through Table 3. These findings open up a number of possible research avenues in the future, not just in the Malaysian setting but also in other developing nations that have to contend with Higher Education 4.0 technologies for instructing and learning. One critical question that stems out from our findings is, what are the barriers that make it difficult for a ‘normal’ lecturer to develop her or his own educational contents that use cutting edge technologies? Other questions might relate to the level of technical and technological knowledge possessed by tertiary lecturers or instructors, and even their actual attitudes and perceptions to the implementation of Higher Education 4.0 educational technologies like 360-degree videos, VR environments and AR materials. Qualitative studies might be suited to study such constructs.

As alluded in the preceding paragraph, Tables 4, 5 and 6 show that the survey respondents are open to the notion of adopting the use of 360-degree videos, VR environments and AR materials for the benefit of their students in universities and polytechnics. The positive attitudes that they show is perhaps also related to their fields of expertise in applied sciences, computer sciences, pure sciences,
engineering, and technical and vocational subjects that should, by right, rely on high-end or novel technologies to impart knowledge to students at tertiary level institutions. In addition, the usage of 360-degree videos, VR environments and AR materials should increase the engagement of students in scientific and technological, and technical and vocational skills with learning tasks that involve experimentation and doing certain actions that should be experienced, first-hand, for the best effects.

Table 4. “I believe using 360-degree videos for subject(s) I teach will benefit my students”

|  | Strongly disagree | Disagree | Fairly disagree | Fairly agree | Agree | Strongly agree |
|  | 9 (5.33%) | 34 (20.12%) | 21 (12.43%) | 31 (18.34%) | 55 (32.54%) | 19 (11.24%) |

Table 5. “I believe employing VR environments for subject(s) I teach will benefit my students”

|  | Strongly disagree | Disagree | Fairly disagree | Fairly agree | Agree | Strongly agree |
|  | 5 (2.96%) | 29 (17.16%) | 20 (11.83%) | 36 (21.30%) | 57 (33.73%) | 22 (13.02%) |

Table 6. “I believe employing AR materials for subject(s) I teach will benefit my students”

|  | Strongly disagree | Disagree | Fairly disagree | Fairly agree | Agree | Strongly agree |
|  | 14 (8.28%) | 31 (18.34%) | 28 (16.57%) | 41 (24.26%) | 39 (23.08%) | 16 (9.47%) |

At the same time, as Tables 4, 5 and 6 show, there are differences in opinions regarding which technology will benefit students most. This might be directly related to the academic subjects being taught by the survey respondents; certain subjects might be suitable for VR environments to enhance the learning of students whilst other subjects might benefit more from the use of AR materials. The same goes with the use of 360-degree videos. The only way to be certain is to carry out further research into the topic of Higher Education 4.0 content development and Higher Education 4.0 educational materials deployment, something that we highly recommend for researchers who are interested in the same subject matters. Tables 7, 8 and 9 below illustrate the findings regarding the match between academic subject matters and the technology to teach those academic subjects.

Table 7. “I think using 360-degree videos is a positive method to reinforce the subject(s) I teach”

|  | Strongly disagree | Disagree | Fairly disagree | Fairly agree | Agree | Strongly agree |
|  | 15 (8.88%) | 37 (21.89%) | 20 (11.83%) | 28 (16.57%) | 51 (30.18%) | 18 (10.65%) |

Table 8. “I think employing VR environments is a positive method to reinforce the subject(s) I teach”

|  | Negative spectrum | Positive spectrum |
|  |  | |
|  |  |  |  |  |  |  |  |
The last tables in this section, Tables 10 through 12 indicate the personal intentions of the survey respondents to develop their own educational materials or contents based on Higher Education 4.0 learning technologies for the academic subjects that they teach in the applied sciences, computer sciences, pure sciences, engineering, and technical and vocational subjects. Although as compared to the three initial tables in this section (Tables 1, 2 and 3), the numbers and percentages are a bit higher, these figures might still be seen as low in the grand scheme of things as Higher Education 4.0 technologies for teaching and learning become even more widespread and more common in highly developed and developing nations around the globe. Furthermore, the intention to carry out or to do something is still not the same as actually doing it, in the real world. And, especially when the figures for educational content development and deployment in the last 12 months are very low, as Tables 1 through 3 indicate.

Table 10. “I intend to create contents using 360-degree videos for the subject(s) that I teach, in the next 12 months”

| Strongly disagree | Disagree | Fairly disagree | Fairly Agree | Agree | Strongly agree |
|-------------------|----------|----------------|-------------|-------|----------------|
| 126               | 43       |                |             |       |                |
| (74.56%)          | (25.44%) |                |             |       |                |

Table 11. “I intend to create contents employing VR environments for the subject(s) that I teach, in the next 12 months”

| No                  | Yes         |
|---------------------|-------------|
| 117                 | 52          |
| (69.23%)            | (30.77%)    |

Table 12. “I intend to create contents employing AR materials for the subject(s) that I teach, in the next 12 months”

| No                  | Yes         |
|---------------------|-------------|
| 133                 | 36          |
| (78.70%)            | (21.30%)    |

5. Closing section and overall conclusions
Several conclusions can be drawn from this empirical research effort with quite a high number of survey respondents (n = 169) who teach applied sciences, computer sciences, pure sciences, engineering, and technical and vocational subjects in universities and polytechnics in Malaysia. Firstly, Higher Education 4.0 content development and materials deployment (i.e., educational materials that they have developed by themselves or with their team members) by Malaysian tertiary
level educators are quite low at this present point in time, as reported by the 169 respondents. Roughly, the figures show only about 1 in 5 or about 1 in 6 of the educators surveyed reported that they have created learning materials that use or employ 360-degree videos, VR environments and AR materials in the last 12 months. However, the intention to develop such learning materials in the next 12 months are higher with between 1 in 4 or about 1 in 5 indicating that they plan to take such actions.

Secondly, there is a gap between actual Higher Education 4.0 content development and materials deployment, and the feelings and perceptions of the respondents. By and large, they seem to harbour positive feelings and have positive perceptions of 360-degree videos, VR environments and AR materials. However, they falter when it comes to actually developing and deploying or distributing such contents for the benefit of their students. Still, this does not mean that they shunned these technologies because there are many other digital or online learning objects that they might have developed, albeit older and less interactive ones as shown in Figure 3.

Figure 3. Digital / e-learning objects from old to new from Adnan, Ya Shak, Karim, Tahir & Shah [1]

The third and final conclusion from this empirical study is quite obvious from the data and the corresponding observations: The topic areas covered in this present study need to be examined more and fast, lest Malaysia be left behind by other rapidly developing nations that are already on the Higher Education 4.0 learning technologies bandwagon. The mindset of Malaysian tertiary educators might still be as `normal’ (traditional) educators who just teach from their textbooks and write on the whiteboard when their students are more familiar and more ready to learn using smartphones and tablets. As it is now, there seems to be unseen walls to the wider embracing of these Higher Education 4.0 teaching-oriented technologies (360-degree videos, VR environments and AR materials) at tertiary level in Malaysian universities and polytechnics. Future research should take heed of these findings.

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