Authentic Assessments for Digital Education: Learning Technologies Shaping Assessment Practices

Tristan LIM[ab]*, Swapna GOTTIPATI[b] & Michelle CHEONG[b]
[a]*Nanyang Polytechnic, Singapore*
[b]*Singapore Management University, Singapore*
*tristan_lim@nyp.edu.sg

Abstract: Assessment is a powerful lever that affects learning. To better inform educators on authentic assessment practices within digital education, this paper takes us through a meta-analysis of existing literature between 2011 to 2021. The study evaluates the following research question: "How are emerging technologies shaping authentic assessment practices within digital education for the period between 2011 and 2023". To aid with the forecasting, we utilize the EDUCAUSE Horizon Reports, which provide the predictions of emerging technology. This study affirms the importance of immersive learning technologies, followed by ubiquitous and adaptive learning technologies as key growth research interest areas impacting authentic assessments in the coming years. Results from this study found that the application of immersive learning technologies on authentic assessments is presently highly prioritized as a research area. However, this may likely be overtaken by applications of adaptive learning technologies in the near future. In addition, the application of ubiquitous learning technologies on authentic assessments offers much promise, having grown extensively in research intensity since 2011, overtaking learning objects. The study can help researchers understand past, present and future metatrends of emerging technologies shaping authentic assessment practices, and identify promising potential areas for research and/or education focus.

Keywords: Authentic Assessment, Assessment Design and Practice, Emerging Technology and Trends, Digital Education, Higher Education

1. Introduction

Digital education system is the incorporation of technologies and tools to assist the teaching and learning process (Williamson, 2016). Over the years, traditional education system is transformed into digitalized modes through computing tools, data mining algorithms, database infrastructures, enterprise architectures, cloud technologies, cyber-physical systems, and software and hardware platforms. Specifically, digital software and hardware systems influence the design and implementation of assessments to large extents (Dillenbourg, 2016).

Assessment is perceived with importance by many scholars as "*the most powerful lever teachers have to influence the way students respond to a course and behave as learners*" (Gibbs, 1999). Assessment practices have been under growing attention (Postareff et al. 2012), with increasing demand for the application of more innovative and effective practices to measure students' achievements, building upon higher levels of accountability and expectations for learning (Asghar, 2012). In digital education, there is a predilection towards connecting assessment activities to authentic and meaningful technology practices similar to the many manifestations of practicing technologists and innovators with diverse tools and processes. To formalize the definition of authentic assessments in this paper, we adopt the definition by National Research Council (1996), which defines authentic assessment as "*assessment exercises [that] require students to apply knowledge and reasoning to situations similar to those they will encounter in the world outside the classroom, as well as to situations that approximate how [practicing professionals] do their work*."

In the educational research setting, most of the questions studied by educators revolve around "*what works*" (Ross, 2017). Education technology is a complex and integrated process that includes defining and designing philosophical and ethical aspects, methodologies and approaches, and

theoretical and applied methods of using technology to support education. On the other hand, learning technology is related to the use of the technology to perform instruction or learning, within educational processes. In other words, learning technology has a more precise scope, and includes an explicit focus on technology, techniques, and strategies for the digital education system. The main aim of this study is to analyze "what works" in the design and implementation of assessments in the digital education system. In particular, we explore learning technologies for assessments to better inform educators on authentic assessment practices within digital education. This paper takes us through a meta-analysis of existing literature on learning technologies between 2011 to 2021. We first extracted the database of emerging technology from the EDUCAUSE Horizon reports (EDUCAUSE, n.d.) and applied bibliometric method to analyze trends and emerging technology, through the indicators including publications, citations, and occurrences of keywords or key phrases.

The study evaluates the following research question: *How are emerging technologies shaping authentic assessment practices within digital education for the period between 2011 and 2023?*

Through an evaluation of the key research question, the study hopes to (i) understand emerging learning technologies and trends, and their influence on authentic assessment practices, and (ii) provide an analysis of how authentic assessment practices may evolve in the coming years. This can help researchers decide where to focus the research efforts in the coming years and the educators on the various assessment models and methods.

2. Trend Analysis

From a well-cited research effort by Martin et al. (2011), the Horizon Report (HR) is a good starting point of reference for an annual technology prediction impacting education. HR explores and predicts technology developments impacting education from a broad perspective, inclusive of teaching, learning, and assessments. Since 2004, HR has released free and publicly accessible annual predictions of key global emergent technologies in education; no other resource has issued annual trend publications for a longer period of time. Published by EDUCAUSE (EDUCAUSE, n.d.), HR has been a widely read and highly regarded educational technology resource for education practitioners. A blunt (but useful) indicator of the volume of references, commentaries or discussions related to HR – with albeit a publication track record of 17 years, approximately 234,000 results can be found from a google search of HR (excluding contents from EDUCAUSE home site) (Google search entry: +*"horizon report" -site:educause.edu*).

The annual HR methodology involves surveying expert panelists to yield trend perspectives – in a short term (year of report), midterm (two to three years from year of report), and long term (four to five years from year of report). It is an ever-fruitful endeavor to continually improve survey methodologies – an undertaking EDUCAUSE undertook since its 2020 report. This resulted in a change in methodology. For each annual publication from 2020, the trend prediction time horizons were removed, in favour of discussions on broad trending technologies and practices impacting education by the expert panelists. In our study, we analysed HR reports from year 2011 to 2021, that cover technology metatrends between 2011 to 2023.

To evaluate metatrend hypotheses, methods including technology investment and sales, technology uptake reports, and patent analyses were considered by several studies. However, these methods yielded unreliable insights (Martin et al., 2011). The former two methods involve quantitative data which were difficult to validate. The latter method of patent analyses relates more to commercial and industry, rather than education-related research, which limited its usefulness. Bibliometric is a commonly applied method to analyze trends and emerging technology, via indicators including publications, citation and occurrences of words, among others (Daim et al., 2006).

In our study, to corroborate results from the metatrend hypotheses, bibliometric analysis is applied. At the time of this work, there are around 5,000 articles relating to education research involving bibliometric analysis on Google Scholar (Google Scholar search entry: *intitle:(education AND bibliometric)*). Recent education-related works that used bibliometric analysis include Huang et al. (2020), and Marín-Marín et al. (2019). Bibliometric analysis requires sufficient and verifiable data for temporal comparison. Google Scholar is a good tool for bibliometric analysis, as it provides a comprehensive, quantifiable, and verifiable search across a wide range of academic repositories, including JStor, Springer, Wiley, Mendeley and IEEE, among others.

3. Research Methodology

This study follows the methodology applied by Martin et al. (2011) for answering our research question. The steps are as follows:

1. *Metatrend review*: Record trends of technologies and/or practices affecting education from Horizon Report between 2011 to 2021. Create visual representation of the trends, by grouping technologies according to their similarities and creating detailed views for each group. Trends of technologies and/or practices that have no relation to assessments are excluded. Analyze the key metatrends observed and map against assessment practices in published literature within the period under study.

2. *Bibliometric analysis:* Perform bibliometric analysis as an objective evaluation of emerging technologies shaping assessment practices. This step includes measuring the impact of predicted technologies in assessment practices, by searching and computing the number of papers published between 2011 to 2021 for each relevant technology group in bibliographic databases. Using Google Scholar as a bibliometric analysis tool, we narrow the scope of selection to the selected technology group, assessment type, education approach, education level, publication title, and year of publication.

3. *Evaluation*: As the number of authentic assessment-related education papers varies each year, a weighting factor is applied to the results for each technology group to allow for comparison across different years. Weighting factor (WF_i), as shown in Equation (1), is computed by dividing the mean number of papers published across the period under study, against the number of publications at year i.

$$WF_i = \frac{\bar{p}}{p_i} = \frac{\frac{1}{N}\sum_{i=2011}^{2021} p_i}{p_i} \qquad (1)$$

where $\bar{p}$ represents the mean number of publications from 2011 to 2021, p_i represents the number of publications at year i, i represents the period {2011, 2012… 2021}, and N represents the total number of years. With the application of the weighting factor, the years with lower publications of authentic assessment-related education papers will not be unduly penalized. Finally, we provide an objective assessment of the HR predictions against the bibliometric results.

4. Results

4.1 Metatrends and Technology Clustering

Results of step 1 of the methodology are compiled in Figure 1. In Figure 1, the rows represent the year of the horizon report, and the columns represent the prediction period of the technologies. Note that prior to 2020, the HR survey methodology predicts the technology trend for the year of the report, for two-to-three years ahead (mid-term), and four-to-five years ahead (long term). From 2020 and beyond, HR only discusses emerging technology trends based on the year of the report as such the forward period predictions of two years and beyond do not apply.

Each technology cluster is grouped by color based on similarity: (i) orange cluster represents technology trends related to ubiquitous learning technologies, (ii) yellow represents technology trends related to adaptive learning technologies (AI), (iii) blue represents technology trends related to immersive learning technologies, and (iv) grey represents technology trends related to learning objects.

4.2 Bibliometric Statistics

A detailed bibliometric analysis research is performed to assess if the defined technology group had predicted impact on authentic assessments in digital education. Figure 2 is the graphical representation of the number of papers available in Google Scholar for each technology group in each of the analyzed years, weighted based on Equation (1).
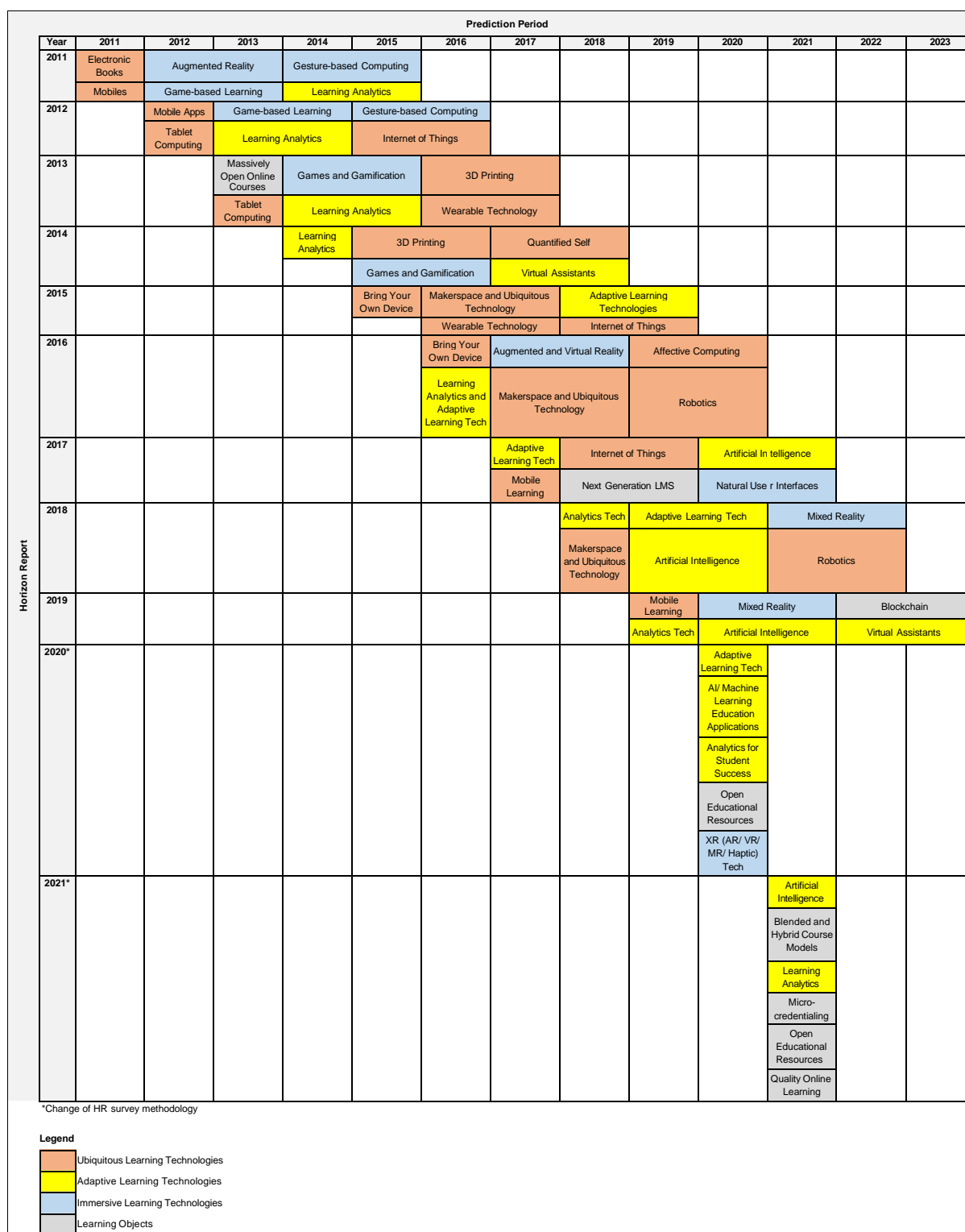
Prediction Period

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
2011	Electronic Books	Augmented Reality		Gesture-based Computing									
	Mobiles	Game-based Learning		Learning Analytics									
2012		Mobile Apps	Game-based Learning		Gesture-based Computing								
		Tablet Computing	Learning Analytics		Internet of Things								
2013			Massively Open Online Courses	Games and Gamification		3D Printing							
			Tablet Computing	Learning Analytics		Wearable Technology							
2014				Learning Analytics	3D Printing		Quantified Self						
					Games and Gamification		Virtual Assistants						
2015				Bring Your Own Device	Makerspace and Ubiquitous Technology		Adaptive Learning Technologies						
					Wearable Technology		Internet of Things						
2016					Bring Your Own Device	Augmented and Virtual Reality		Affective Computing					
					Learning Analytics and Adaptive Learning Tech	Makerspace and Ubiquitous Technology		Robotics					
2017						Adaptive Learning Tech	Internet of Things		Artificial Intelligence				
						Mobile Learning	Next Generation LMS		Natural User Interfaces				
2018							Analytics Tech	Adaptive Learning Tech		Mixed Reality			
							Makerspace and Ubiquitous Technology	Artificial Intelligence		Robotics			
2019									Mobile Learning	Mixed Reality		Blockchain	
									Analytics Tech	Artificial Intelligence		Virtual Assistants	
2020*										Adaptive Learning Tech			
										AI/ Machine Learning Education Applications			
										Analytics for Student Success			
										Open Educational Resources			
										XR (AR/ VR/ MR/ Haptic) Tech			
2021*											Artificial Intelligence		
											Blended and Hybrid Course Models		
											Learning Analytics		
											Micro-credentialing		
											Open Educational Resources		
											Quality Online Learning		

*Change of HR survey methodology

Legend

- Ubiquitous Learning Technologies
- Adaptive Learning Technologies
- Immersive Learning Technologies
- Learning Objects

Figure 1: Emerging technologies impacting education based on Horizon Reports from 2011 to 2021.

5. Discussion

Immersive learning technologies generated the highest publication interest as of 2021, after weighing the effect of overall publication numbers. Its publication numbers were consistently around 800 to just under 950 per annum between 2011 to 2021. It was consistently mentioned in nine of the 11 years under study in HR. The consistency in research interest is evident in the continued HR predictions tied to immersive environment-related education and assessments, including game-based environments, and mixed reality environments (e.g., virtual reality, augmented reality). While the initial cost for equipment

and development of the immersive assessments may be high, this is arguably offset by the relatively cheap adaptation of the content for different authentic scenarios, the lower cost of maintenance, ease of portability and the relatively modest space requirement (Engelbrecht, Lindeman & Hoermann, 2019). This technology area has high ecological validity for authentic assessments but is still plagued by issues such as relative immaturity of technology, uncertain skill transfer, and lack of specialization and testing of systems.
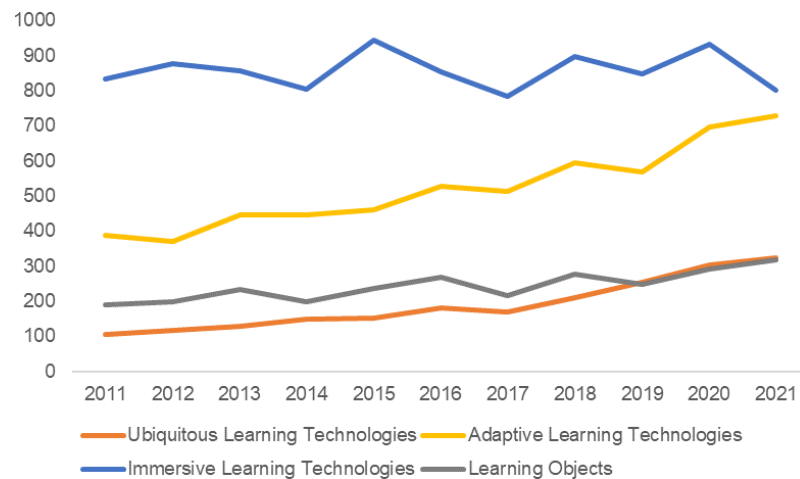
Figure 2: Number of papers published in Google Scholar in each technology group between 2011 to 2021, adjusted with weighting factor in Eq. (1).

Adaptive learning technologies generated the second highest publication interest as at 2021, after weighing for the effect of overall publication numbers. It is noteworthy that while adaptive learning technologies represented less than half of the research interest in immersive learning technologies in 2011, the gap between the two technology groups has shrunk to less than 10%. In fact, the weighted number of publications on adaptive learning technologies almost tripled in the 11 years under study. There are well documented ethical debates regarding the use of AI in assessments, and in particular, grading. However, among other benefits, the possibilities of the use of analytics and AI in assessments as part of an authentic learning intelligent tool to measure personalized cognitive skills, and provide analysis and feedback of learner performance, progress and potentials are highly useful (Chassignol et al., 2018). Adaptive learning technologies trended across all of 2011 to 2021 in HR. If allowed to continue in its current trend, it is expected that assessments driven by analytics and AI will take a larger role in the coming years.

Ubiquitous learning technologies generated the third highest publication interest as of 2021, after weighing the effect of overall publication numbers. The weighted number of publications started from a low base of 107 in 2011 and ended the period under study by tripling to 323, overtaking learning objects. Ubiquitous learning technologies trended across all of 2011 to 2019 in HR. While there is resistance to the adoption of assessments tied to ubiquitous learning technologies, e.g. possibility of cheating owing to poor monitoring mechanisms, changes in socialization dimensions from group to individual, and cost of implementation (Sophonhiranrak, 2021; Asiimwe & Khan, 2013), most threats are surmountable and ubiquitous learning technologies offer many opportunities in enhancing the authenticity of digital education. The tripling of weighted publication numbers during the period under study is a testament to the growing interest in assessments tied to ubiquitous learning technologies. This technology group is an area that has much potential to explore in the coming years.

When weighted for the effect of overall publication numbers, it is observed that assessments tied to learning objects generated the lowest publication interest as of 2021. Correspondingly, learning objects were mentioned the least in HR – only in five of the 11 years under study. The higher mentions in HR from 2019 onwards, is in line with the growing research since 2019. These coincided with the effects of Covid-19 on broad-based education, including assessments. It is observed that learning objects only started receiving more mentions in recent years in HR, owing partly to pandemic-related need for assessments tied to more quality online courses (including micro-credential short courses), blended and hybrid course models, and open educational resources.

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6. Conclusion

The findings provide a clear evolution of trend which can be used for future trend predictions for focus research and/or investment areas. Adaptive learning technologies, albeit being the second most highly published area in 2021, is highly likely to surpass immersive learning technologies as the number one research area in the near future. Further, having tripled in publications over the past 11 years and having overtaken learning object in research intensity, ubiquitous learning technologies showed promising potential as focused research and/or investment area.

Technology is growing at a rapid pace at multiple directions. Future research can look to provide a more detailed, mapped and streamlined guidance on how each technology area (or sub-areas) can influence assessment practices, with illustrations of such assessment practices for educational or research practitioners. It will also be useful to consider research similar to the Gartner Hype Cycle (Perez & Kreinovich, 2018) for emerging technologies and trend that may significantly affect assessment practices, to inform and prepare educators and researchers for potential changes coming in the years ahead.

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