REVAMP: Transforming Technology-enhanced Education to Cater for Learners' Dispositions

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Abstract
The integration of technology into an education system is a precarious affair that prompts educators and policy-makers to refer to various technology implementation guidelines including but not limited to Technology Acceptance Models, Gilly Salmon's 5 Stage model, Puentedura's SAMR model, or Koehler's TPCK model; to name a few. The integration of technology involves the aspects of management systems, digital tools, the learners and the learning process – creating an intricate nexus of exponentially evolving components requiring 21st century skills. The increasingly rapid development of technology contributes to digital obsolescence; and the unquestioned belief (doxa) that learners are able to shift their use of technology for learning when predominantly their uses are for entertainment and social purposes predisposes them to selective technology types (hysteresis). One challenge of implementing new learning technologies is thus in identifying which tools or systematic collections of tools are applicable to the target learners and their dispositions to using technologies for learning. Concurrent to the body of literature focusing on online learning technologies, there is a prevalent trend in social science research that puts focus on the learner. This paper proposes a new model, called the REVAMP model, to establishing educational technologies that significantly contribute to transforming education to cater for learners' dispositions by providing systems and approaches that are (1) realistic, (2) engaging, (3) virtual, (4) adaptive, (5) multimodal, and (6) personalised.

Keywords: Digital Transformation, Technology-Enhanced Learning, Dispositions, REVAMP

Introduction

The digital transformation of education is an increasingly deliberated discourse among policy-makers, education agencies, educators and researchers alike; and has become a developing research interest rushed and expedited by the current global pandemic – Covid-19. For the education sector, digital transformation occurs in the aspects of (1) education management and (2) teaching and learning.

The education management aspect involves matters concerning policies, decision-making, legal, human resource, and the financial management constituents of integrating new technologies. Factors that attribute to education management include policies, big data and data analytics, data protection and governance, decisions on return of investment and/or equity, and research on the state-of-the-art that result in white papers and blue papers. In educational research, these fundamental components of how educational agencies operate are often overlooked in educational research as they are less relevant responsibilities of teachers and educators.

Areas where teachers and educators are more invested and involved in reside in the teaching and learning, and for which digital transformation encompasses the selection and use of learning management systems, standalone educational applications and software, digital curriculum content, technology-enhanced learning solutions and the pedagogical approaches to delivering them; matters that are more exhaustively covered in the body of educational research literature. Notable examples include but is not limited to Mishra and Koehler's TPCK Model (Koehler and Mishra, 2008), Puentedura's SAMR Model (Puentedura 2010; 2013) and Salmon's 5-Stage Model (Salmon, 2013).

Regardless of the distinction between the two responsibilities undertaken by an education agency, more so an agency that regulates education at a state level such as a Department or Ministry of Education, the factors of education management is expectedly concomitant to the success rate of teaching and learning that occur in schools, classes and lessons. Despite this concomitance, a large portion of research related to addressing the digital transformation of education is not only far more inclined towards developing solutions to schools, classes and lessons, they are for the most part detached from these requisites that occur on the macro-level. These requisites are the decisions made in ensuring cost-efficiency, resiliency, reliability, longevity, sustainability and agility of newly introduced technology and technology systems, concerns that inherently educators and researchers may not be privy to.

Nevertheless, for many years' state education agencies remain focused on assisting teachers and students to develop digital competency and inculcate the use of technologies to then expect them to improve learning performance and learning experience, various experts have developed fascinating models as mentioned earlier to guide teachers and educators on the components that make a functional digital learning environment or ecosystem. These models emphasise on learning platforms and processes that are interactive, authentic, conducive and attractive. They aim to further enhance or replace the learning dynamics that already have proven success in the traditional classroom, such as groupwork, problem-based learning, student-centred learning and so forth.

Given the context whereby the digital transformation of education is a binary of either education management transformation or teaching and learning transformation, this early-

stage research and consequently literature review paper elucidates on the creation of a digital transformation framework that considers both sides of the equation.

1. Preliminary Research

Prior to developing the framework based on preceding literature, this paper employed a meta-analysis consisting of a series of quantitative studies that were conducted since 2016 in measuring learners' dispositions towards learning using technology (Omarali 2016; 2017a; 2018; Omarali and Motteram, 2017).

The studies all employed an online closed-ended questionnaire instrument that contained 26 5-point Likert-scale items that were found to reveal aspects that align with learners' diverse dispositions. In previous studies, the said instrument was used as part of a mixed-method research with a qualitative data collection instrument (either interviews, focus groups or Netnography), designed to be analysed using multivariate analysis such as Factor Analysis and Correspondence Analysis with the objective of identifying the learners' dispositions toward their preferred method of online learning delivery. This paper flips the focus from identifying the learners' dispositions to identifying the design of the online learning ecosystem itself.

Data from all the referred studies were meta-analysed based on frequency descriptive analysis. Combining 5 separate studies, the sample comprised of learners from multiple demographics and countries, notably (1) postgraduate students (n=149), (2) technical vocational education students (n=407), (3) online students (n=20 + n=16), and (4) middle school students, and high school students (n=263). Every sample group attempted the same 26 items. Altogether, the sample for this paper is n=855. The meta-analysis unearthed thematic patterns on which a learning ecosystem can be described, viz. the level of learner engagement (E), content multimodality (M), learning adaptiveness to learner dispositions (A), personalisable learning experience (P), and virtualisation (V) of the user interface for the previous four themes.

Upon positioning these five themes against the requisites of education management, an additional theme (Realistic Deployment (R)) was added to the five themes to represent decision-making governed by policies, resources, data analytics, data protection, finance and other operations that would differentiate any digital transformation proposal from being idealistic to being realistic and achievable. At this research juncture, the themes were referred to as Aspects and the 26 items of the instrument reorganised based on the six Aspects – REVAMP (Table 1).

A majority of these items cut across several aspects but the purpose as temporary placeholders in progressing towards a systematic literature review, the items were listed under the aspect that they would align with the most. For this study, the items were rearranged according to the REVAMP framework.

Aspect [Item]	*x*
Realistic (the deployment)	**R**
01. [Sufficient money to spend on what I need]	2.26
Engaging (the platform)	**E**
02. [Skip information that I don't like or find boring]	4.11
03. [Concentrate better when doing activities online]	3.45
04. [Online groups]	3.03
05. [Never get lost in the large amount of internet information]	1.68
06. [Am always calm and stress-free]	2.76
07. [Browsing the internet for information]	4.01
08. [Use it continuously throughout the day]	3.81
09. [Interactive software]	3.24
Virtual (existing processes that are virtual)	**V**
10. [Am motivated to learn when using the internet]	3.24
11. [Consulting my teachers]	2.28
12. [Seek the opinions and advice of others]	2.61
13. [Watching how others do their work]	2.94
14. [Communicate with people easier online]	3.28
Adaptive	**A**
15. [Strong ICT skills due to the support I have]	2.10
16. [Do multiple things at the same time (multitask)]	2.52
Multimodal	**M**
17. [Reading printed books or notes]	1.84
18. [Mobile apps for activities and accessing notes]	4.17
19. [Online notes that are readable/ downloadable]	3.85
20. [Watching videos]	3.92
21. [Group work]	3.33
Personalised	**P**
22. [Firstly plan on how I will do my work]	3.44
23. [I first go to websites that I am most familiar with]	3.20
24. [Choose the easiest/ most convenient internet feature]	3.98
25. [Work at my own pace]	3.08
26. [Expect to quickly find the information I need]	3.19

Table 1: Mean Scores Per Item of REVAMP

Out of the 6 aspects, the Aspect ‘Realistic’ was least represented with only 1 item attributing to it. This is in part because the 26 items were used in studies that collects the opinions of learners, and as mentioned earlier in this presentation, learners and teachers would have more idealistic expectations of what makes a successful learning system. Which is why a better measure of the Realistic Aspect would be through using question items directed to policy-makers.

The intention of this meta-analysis was to first and foremost discover if any patterns exist that supports REVAMP based on responses to 26 items. In terms of educational research, this

absolutely falls short of fulfilling the considerations in producing statistically significant results. The statistical evidence to support this REVAMP framework is after all an early-stage research; a work-in-progress. At this juncture, conducting studies to understand, to map, and to frame the digital transformation of education that considers both education management and teaching and learning would benefit from a complementary systematic review of the literature.

A literature review that supports the development of a framework to guide the digital transformation of education based on the six identified aspects is a good starting point to develop further research studies with more in-depth data analyses of data from the end-user stakeholders and the policy-maker stakeholders; using the same framework and data collection instrument that befits the REVAMP model. As the research build towards a digital education system that integrates inseparable singularity, the more prepared will stakeholders be in making that large-scale transformation seamless, less disruptive, and fulfilling for all involved.

2. A Review of the Literature

In 2011, Selwyn stated that "digital technology is a key element in sustaining the long-established links between the needs of a country's economy and the nature of a country's education system". Fast-forward several years, the World Economic Forum in their The Future of Jobs Report 2018 predicted the loss of 75 million jobs by 2022 with the four main drivers of change in the job market being ubiquitous high-speed mobile internet, artificial intelligence, big data analytics and cloud technology (WEF, 2018). Nevertheless, the future world of work is not as bleak provided that societies transition into the new digital world, with digital technologies expected to create 133 million job opportunities. They key catalyst for these jobs is an enhancement to the digital revolution - the 4th industrial revolution - and the process to reaching this 4th industrial revolution is Digital Transformation.

2.1. Digital Transformation and Education

However, despite the emphasis on digital transformation as the conduit to new professions, the main custodian of employable skills and knowledge - i.e. the education sector - rarely aligns its decades of initiatives under the nuances of educational technology and technology-enhanced learning with digital transformation. Perhaps, teaching and learning are more often handled at granular level that transformation occurs at ground-level in these microcosms of schools, classes and lessons. What is evident from literature is that digital transformation is rarely associated with education.

It wasn't until the year 2008 that a journal article on digital transformation was first published. And two years after in 2010, the phrase 'digital transformation in education' was used by then US Secretary of Education Arne Duncan in his address during the State Educational Technology Directors Association Education Forum. But other than these two recorded references, the concept of digital transformation in education was hardly ever mentioned, in comparison to for example – e-learning, online learning, technology-enhanced learning or computer-assisted learning. These were the terms that resonated more, because the idea of education and technology becoming an inseparable singularity was not a research priority at the time, because technology in learning transpiring then did not yet immensely contribute to creating a gap, a dissonance in performance and access to knowledge that is increasingly digital.

Hence, the digital transformation of education is nothing new. It is just that the movement was never coined before as 'digital transformation'. The body of literature that refers to the integration of digital technology and internet technology into teaching and learning, into schools and lessons, oftentimes refer to it as e-learning, computer-assisted learning and technology-enhanced learning or some phrase similar to these terminologies. Examples include Mishra and Koehler's TPCK Model since 2006; Ruben Puentedura's SAMR Model since 2010 which addresses transformative applications of information technology into education; several educational technology acceptance models (TAM) dating back to 2002 with the study of TAM in evaluating the efficacy of internet-based education systems. Faculty and educators have embraced Gilly Salmon's five-stage model. Before the turn of the 21st century, Dr. Gilly Salmon was already researching on online technology in regard to online learning environments, moderation of learning, computer-mediated communication. Certainly, various experts have made great strides in preparing practitioners, whether it be teachers or policy-makers, on what makes digital technology effective in teaching and learning.

These models of enhancing learning dynamics tend to have a top-level. For the TPCK, the central model TPCK is its top level. For the SAMR model, the Redefinition Stage is the top level, but in order to reach it the system has to fulfil the stages of substitution, augmentation and modification. The same can be said for Salmon's 5-step model, the top level is the 5th Stage (the Development Step) and to arrive to that stage entails the fulfillment of the previous 4 stages in the model.

2017 was the year when the topic of digital transformation in education finally became one of education sector's main discussions. Whether the Industry 4.0 declaration in 2016 instigated it or whether respective societies are being instinctively awakened by new observations of how more dependent societies are to technology, the idea of transformation finally trickled into educational research. In 2016, less than 10 published research papers were dedicated to the topic. In 2017, 39 papers were published on digital transformation in education. In 2018, 47 papers. In 2019, 84 papers. In 2020, more than 120 papers. Indeed, educational researchers are more aware that education and technology will likely become an inseparable singularity. However, 'awareness' is merely diagnostic data. What is more important is predictive data – preparedness. Preparedness is a whole different proposition, and one that will benefit from a framework for both policy-makers and educators to work together towards seamless transformation. The REVAMP Model, informed in the future with predictive data, intends to prepare education agencies handling both education management and teaching and learning with an insight on digital transformation that caters for learners' diverse dispositions while in tandem realistic deployment of projects that constitutes the digital transformation.

2.2. The REVAMP Framework

2.2.1. Keeping it Realistic

The first REVAMP Aspect is Realistic. It is easy to be fascinated by the idealistic features of emerging technologies. Certainly, the affordances offered by gesture-interface, algorithm-based learner diagnosis, or augmented reality interaction are for example strong reasons for deploying them in lessons. From the policy-maker perspective however, the reality of the situation is that there exist limitations to how far idealistic solutions can be realised. The first limitation is resources, and resources can be further broken down into financial resources, human resources, time resource and infrastructural resource.

On financial resources, most emerging technologies are costly to deploy. The cost increases based on the uniqueness the technology offers. For example, a Google Cardboard kit may cost less when compared to an HTC Vive Pro headset. In reality, an HTC Vive Pro headset offers far more features than a Google Cardboard, relative to their price points. On human resources, superior emerging technologies tend to have more complex hardware, firmware and codebases. In turn these complexities require considerable human resource as technical support. Adding to this, to account for making different technologies work together in singularity, with the ability to be interconnected and interoperable, with technologies such as API, SCORM, LTIs and Single-Sign On. Another variable is the end-of-life of technologies. Any human resource dedicated to handling digital transformation have to be a few steps ahead in terms of planning, migration, development and implementation of replacement technologies, or even better, the prospect developing learning technologies in-house.

The second limitation is access. There exist pertinent concerns on inequity and inequality, and many reports and literature have supported that digital technologies, when not implemented properly, exacerbate inequity and inequality. Bridging the digital gap and digital dissonance that emerging technologies bring should be considered as a main part of the REVAMP framework. Limited access can be caused by an agency not having the resources mentioned, but also that an agency has less control of end-users' access limitations and ownership of required technologies. For example, High-Definition videos may be a more engaging immersive experience, but do the user demographic all have access to devices that accommodate high definition? Do the user demographic have secure economic resource to sustain the high bandwidths needed? Would the agency be willing to demand from users to equip themselves with technologies that they cannot afford? These are questions that the REVAMP framework intends to address.

The third limitation is Return of Investment. Education agencies are expected to have the best interest of the students in mind. However, any agency that wants to remain systematically operational would still want a well-run business. Implementing technologies require budgeting and financial commitments, and for organisations they regard the cost-benefit of implementing or procuring or spending human resource to develop these technologies, in terms of Return of Investment. Monetary returns asides, returns are rather in terms of having students experiencing quality education which in turn produces graduates who have diverse and future-ready skillsets, which in turn contributes back to the education system with new knowledge and new innovation.

Currently, there is a dearth in research on the significance of maintaining the realistic educational technology deployment. Even when referring to the models of what makes successful technology-enhanced learning, the role of realistic solutions is often overlooked. The search only unearthed 7 publications on realistic implementation of educational technology (Fisher, 1996; Garba and Garba, 2008; Eggins, 2011, Hanlon, 2015; Xianmin et al., 2017).

2.2.2. Engaging

The second REVAMP aspect is Engaging, and specifically 'engaging' as an adjective for learning rather than 'engage' as in the verb 'to use' because in the literature the verb engage has been overly used as a synonym to the word 'use' when in fact engaging as an adjective defines productive interaction, defines that the learner is engrossed, is absorbed in the interaction, defines that it activates the learner's cognition whether it be higher order

thinking, metacognition, experiential learning, problem-solving, enquiry-based, discovery learning, authentic learning, action learning, human-computer interaction, constructivist learning, or any combination of these engagements.

Based on this definition, a scoping search of the literature since the advent of the Internet found 20 articles dedicated to engaging learning systems (Hawkes et al; 1999; Kearner and Maakrun, 2020; Lawrence, 2011; McEvoy and Cowan, 2016; Oulaich, 2019). These comprise of engaging interactions such as gesture-based interactions (Tootell et al., 2013), gamification (Annetta et al., 2011; Lamprapoulos et al., 2019; Mageswaran Sanmugam et al., 2015; Sanmugam et al., 2015; Talbot et al., 2012), digital storytelling (Bromberg et al., 2013; Sadik, 2008), e-learning tools (Cherner et al., 2019; Mehlhorn et al., 2011; Rohrbach et al., 2014; Uhomoibhi et al., 2019), and learning by play (Ernst et al., 2015, Levesque, 2006; Stieler-Hunt, 2016).

A measure of engagement is when the type of content piques the interest and curiosity of students, However, measuring this by observation can be deceptive. Moreover, activities where students passively sit or watch or listen can be engaging but is passive engagement itself productive? Students today have developed different and diverse patterns of attention span, multitasking and memory retention, and it is thus the best interest of the REVAMP framework to figure out if the technologies being deployed indeed align to these patterns.

2.2.3. Virtual

The third REVAMP Aspect is Virtual or Virtual-Ready. The virtualization of learning experience and/or environment is subjective to what is considered virtual. A virtual learning environment for example, is regarded as virtual presence even when that presence is reduced to text-based representations such as posts in discussion forums and text comments on work exercises (Omarali, 2017b). At the other end of the spectrum is virtual presence in the form of avatars in virtual worlds such as Secondlife, AltSpace VR, VRChat, Facebook Horizon, and other similar platforms.

In between the two extremes exists virtual labs (Xin, 2008) where hands-on virtual practicals can be simulated, and virtual tours where students acquire a virtual first-person point of view. Webinars and teleconferences are often associated with virtual learning or virtual classrooms, but considering that users represent their true form in online face-to-face communication, webinars are no more virtual than the depiction of people on television. For digital presence and experience to be virtual, the user has to be digitally represented as a virtual twin. Likewise, the landscape has to be digitally represented as a virtual twin. On 1st March 2021, the ECMWF announced a project called DestinationEarth which is a replica of planet Earth.

Virtual reality technology has been an exciting prospect that it is commonly portrayed on television and movies since the 1980s. It is thus not surprising that a scoping review of the literature on virtual reality itself found more than 900 papers, more than 100 of these were on virtual reality and education (Pantelidis, 1991; Read and Sykes, 1999; among many others), and more than 300 of these on virtual learning environments (Cunha et al., 2008; Farrell, 1999; 2001; Keller, 2005; Metes et al., 1995; among many others).

2.2.4. Adaptive

The fourth REVAMP Aspect is Adaptive. A scoping search of the literature found more than 180 papers on adaptive learning whether it involves technology or no technology. Of the 180, 32 papers associated adaptive learning with education technology. Of the 180, 51 papers associated adaptive learning with technology-enhanced learning. Of the 180, 25 papers associated adaptive learning with digital education.

In the traditional classroom, an observant teacher constantly assesses each learner's satisfaction and learning effectiveness through formative input, performance scores and their learning behaviour. This approach is called differentiated instruction whereby it involves "a teacher attending to the learning needs of a particular student or small groups of students, rather than teaching a class as though all individuals in it were basically alike" (Tomlinson and Allan, 2000, p. 170).

An alternative to teacher-based differentiation is having a digital learning system that adapts to the preferences and abilities of the learners. An adaptive learning system is quicker in formatively assessing learners, and the repetitive matching of similar learner types with learning processes results in a profiling database that can be reused and referred for future learner cohorts. Ghorbani and Montazer (2015) has demonstrated through their Automatic Learners' Personality Identifying System (ALPIS) prototype that adaptive systems are more systematic in their assessment of a learner's current learning need. The experimental ALPIS technology uses an intricate fuzzy inference algorithm that formulates profiles based on learners' patterns of engagement with the system.

The substitution of the teacher with digital technology however is not the easiest of tasks, for the technologies that are comparable to teacher presence are either based on complex algorithms that require technical expertise (e.g. ALPIS), or the still developing field of artificial intelligence to replicate the expected humanistic sensitivity when teachers subjectively and holistically assess their learners needs. These challenges however should not thwart the option of adaptive learning management systems as according to Bayne and Ross (2016) the technology of intelligent systems is a new frontier in teaching that should be embraced (p. 125). An adaptive learning system is expected to be an automated technology that tailors the learning based on its impression of the learner, whereby "[the] gathered information about learners can help system designer to develop a matching, relating and inferring mechanism with digital resource of learning object repository, and then generate the content, context and information that learners need" (Lin and Kuo, 2005, p. 2). The realisation of adaptive learning technology has been enhanced with the advent of artificial intelligence, business intelligence and data analytics in education management.

2.2.5. Multimodal

The fifth REVAMP Aspect is Multimodal or Multimodality. This paper's scoping literature review found that between 2015 to 2020, 22 papers on multimodality and digital learning have been published. From the 22 pieces of literature, six were specific to technology-enhanced learning, and one was specific to educational technology. The literature revealed that the multimodality of a learning system is represented through several forms. Mahfouz and Ihmeideh (2009) conceptualise that, "in multimodal learning environments, learners exert more control over the learning situation, and the multimodal synchronous interactions allow

learners to combine text chat, audio chat and even graphics, thus working collectively at a distance in a multimodal and multidimensional learning environment" (p. 210).

Firstly, multimodality can refer to content. There is the multimodality of how content is delivered and in what format it is being offered. Studies on multimodal online notes included the use of different multimedia, in particular verbal and non-verbal forms (Moreno and Mayer, 2007), and the multiple formats of learning via text, video, audio, images and interactive elements (Sankey et al., 2010). Secondly, multimodality can refer to the learning technology. This exists in the form of the various technologies that are used to interact with learners and teachers. Studies include the use of different narrative approaches in gamified learning environments (Dickey, 2006), the use of several communicative features such as chat rooms, forums, audio and video conferencing to interact (Hampel and Hauck, 2006), the combining of audio, text and graphics (Hampel, 2006), webcasting and online text-chat (King and Fricker, 2007), and the likely discipline-specific use of gestures, speech, facial expressions and graphical inputs (Bunt and Romary, 2002).

Thirdly, there is the multimodality in instruction and pedagogy. Several studies include having alternative instructions to reach a shared outcome or end objective (Whittington, 2010), and the human-computer interaction based on multimodal instructions delivered by a robot (Wolf and Bugmann, 2006). This form of multimodality is the least researched, and it may be due in large part to reliance in algorithms or artificial intelligence to deliver tailored instructions.

2.2.6. Personalised

The sixth REVAMP Aspect is personalisability. A scoping review of the literature found 20 papers on personalisable digital learning, 11 papers on personalisable technology-enhanced learning, and 6 papers on personalized educational technology

Personalised Learning is a relatively new concept that was first mentioned in 2006 in conferences on learning technologies. Van Harmelen (2006) defines a Personalised Learning Environment as "a single user's e-Learning system that provides access to a variety of learning resources, and that may provide access to learners and teachers who use other PLEs and/or VLEs" (p. 815). The main difference between this system and pure VLEs is that the affordances, artefacts and tools involved are selected and structured together by the learner to create his/her own system.

Attwell (2007) describes Personalised Learning Environment as a system that "comprised of all the different tools we use in our everyday life for learning [and that] many of these tools will be based on social software" (p. 4). The use of social software is prevalent in learners for social and entertainment purposes, which is why the idea of Personalised Learning Environments has been an attractive proposition. However, not all studies advocate the suitability of social software for learning. One main concern of using personalised learning systems and why despite it being an attractive option it is still rarely prescribed as a standalone system over structured learning management systems is because of its association with the use of social software.

Nevertheless, a study by Conole et al. (2008) argue that the perception of disruption has changed and that learners are able to integrate these disruptive technologies into their learning without much disruption, so much so that learners professed of learning more

effectively compared to using exclusively prescribed learning management systems which was disliked by 9 out of 10 learners (Conole et al., 2008). Thus, personalisable systems have a strong advantage over non-personalisable systems as they seamlessly complement learners' lifestyles.

Conclusion

This paper proposes a framework that accounts for both education management and teaching and learning. Its six aspects represent solutions that are relevant to both sides of digital transformation on education. In addition, unlike existing models, the REVAMP framework has no top-tier level. It follows a flat holocracy of six aspects of digital transformation that is all-or-nothing. The REVAMP model draws from the agility and scalability of each of its six aspects depending on the developing trends of learning technologies in the foreseeable and perhaps distant future. Educators and schools may have ideas on what makes successful digital learning ecosystems, but the external variables and factors to implementing them, particularly when it is a full-scale implementation, should account for factors that ensure teacher workload is not overburdened in the long-run with perennial training on new technologies, and teaching is not disrupted by abrupt changes in technologies due to digital obsolescence.

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