DEMOS

THE LEARNING CURVE

ANNEX 1: HORIZON SCAN

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HORIZON SCAN: NEW FORMS OF LEARNING

The internet and new, internet-enabled technologies are radically changing what and how we learn. These technologies are both enhancing existing methods of learning, enabling entirely new forms of learning. In this section we provide an overview of a number of new forms of internet-enabled learning and the impact that they are having on how we learn.

A recent government review of online learning and artificial intelligence in education outlines five distinct types of technology-enabled learning: adaptive educational systems, game-based learning, intelligent tutoring systems, interactive learning environments and open learner models.[1] This horizon scan finds that, in addition to these, there are other important types of learning enabled by the internet, including exploratory and contextual learning, and simulation.

Exploratory and contextual learning

Search engines have enabled new forms of learning. The use of search engines generally falls into two categories: information retrieval and information seeking. Information retrieval is not necessarily a form of learning, though it may support it; for example, looking up known reference materials to reexamine them and combine them with other sources to learn new insights. Compared with information seeking, that is a fundamental part of learning[2] - one cannot learn without first seeking out information.

The use of search engines and information query systems are evolving with the spread of chatbots and voice assistants, such as Alexa, Siri, Cortana, and the Google Assistant. There is currently limited evidence of the effectiveness of these systems being used in formal educational settings; initial studies show some positive effects, but further research is needed before these can be claimed to enhance formal learning.[3]

Importantly, though, these systems could aid learning for certain groups of the population that struggle with traditional learning methods. Learning in a more verbal manner, via the use of chatbots and voice assistants, may help those that struggle with reading and writing, for example.This could be particularly empowering for blind learners, providing them with greater convenience and the opportunity for more independent learning.[4]

The integration of voice assistants into devices and the spread of the internet of things - the connection of everyday objects to the internet - creates the potential for greater contextual learning.[5] Contextual learning takes place within the context of the use of the skill being acquired; smart fridges, for example, could offer recipe recommendations and cooking tutorials based on the contents of the fridge. An autonomous vehicle could become a tour guide for passengers, offering them contextual information about their surroundings based on its sensors,

1 The Department for Education (2016) Review of the online learning and artificial intelligence education market, p.27.
2 Marchionini, G. (2019). Search, sense making and learning: closing gaps. Information and Learning Sciences.
3 Terzopoulos, G., & Satratzemi, M. (2019, September). Voice Assistants and Artificial Intelligence in Education. In Proceedings of the 9th Balkan Conference on Informatics (pp. 1-6).
4 Ibid.
5 The Internet of Things refers to a trend of devices and appliances that have sensors built-in and which are networked together, generally through Bluetooth or Wifi, though it is anticipated that 5G will be a major enabler of their connectivity.

passenger queries and existing knowledge of the passengers.

Simulations and on-demand physical models

From apps and videos to Virtual Reality (VR)[6] and Augmented Reality (AR)[7], new technologies are opening up opportunities to transport the learner to formal and non-formal learning situations.

In formal learning contexts, simulations can be used to help learners experience scenarios that might be otherwise difficult or expensive to access. As Case Study 1 demonstrates, simulations are already being used for training purposes in the medical profession. This is just one example of its application, others include frontline work in US and UK police forces.[8]

CASE STUDY 1: TOUCH SURGERY FOR TRAINEE SURGEONS

The app Touch Surgery is being used internationally to deliver tailored training for residency programs (hospital surgical training programs).

The app offers surgical simulations that provide a realistic and detailed guide to every step of a procedure. This means users can instantly test their knowledge and rehearse for surgery through an iterative and deliberate learning process, receiving consistent feedback and crucially without risk to patients.[9]

Touch Surgery has been validated by more than sixteen independent peer-reviewed publications as an effective training tool across eight specialties - including orthopaedics, general surgery, plastic surgery and neurosurgery - and across both high income and low and middle-income settings.[10]

Touch Surgery also offers an AI-powered surgical video management platform for students to learn from. [11]

Virtual Reality (VR) is playing an increasingly important role in the museum sector, from enhancing the physical experience of visitors, to allowing people with accessibility requirements to view exhibits online. Improving access to archaeological sites is a further example of the use of these technologies. The use of VR and AR can improve access to archaeological sites for those that would not be able to visit the sites, be it due to financial, geographical or mobility barriers.[12] Further, these technologies could help improve the sensory experience at the sites for those with disabilities.[13] AR and VR technologies are also being used in a bid to democratise museums and other traditional learning environments. The MoMAR app, for example, uses Augmented Reality to allow visitors to New York's Museum of Modern Art to overlay existing artwork with new images, or to alter the existing artwork, to provide a different interpretation of artwork. The aim of the app is to democratise "physical exhibition spaces, museums, and the curation of art within them."[14]

6 Defined as a computer-generated 3D environment, that the user can navigate and interact with, resulting in real-time simulation of one or more of the user's five senses. For more: Yung, R., & Khoo-Lattimore, C. (2019). New realities: a systematic literature review on virtual reality and augmented reality in tourism research. Current Issues in Tourism, 22(17), 2056-2081.

7 Defined as the enhancement of a real-world environment using layers of computer-generated outputs (including images, sound, video, GPS, etc.) through a device.

8 Luke Durhmel (2018) Welsh police force is first in U.K to use virtual reality to train its officers. Digital Trends. Online at https://www.digitaltrends.com/cool-tech/uk-police-virtual-reality-training/ (accessed 13/02/2020); Charlotte Bowe (2018), Inspector introducing VR technology to Police Tactical Training Centre. The Northern Echo. Online at https://www.thenorthernecho.co.uk/news/17564942.cleveland-and-durham-police-training-centre-in-virtual-reality/ (accessed 13/02/2020); Jonathan Saunders (2018), Counter-terrorism police are now training with virtual terrorists, Sheffield Hallam University. Online at https://www.shu.ac.uk/research/in-action/projects/virtual-reality-training-for-counterterrorism (accessed 13/02/2020).

9 The Royal College of Surgeons (2019), The Future of Surgery, p.73. Online at https://futureofsurgery.rcseng.ac.uk › report (accessed 13/02/2020).

10 Ibid.

11 Touch Surgery (2020). Webpage. Online at https://www.touchsurgery.com/ (accessed 13/02/2020).

12 Brenden Cassidy and David Robinson (2017). How virtual reality is opening up some of the world's most inaccessible archaeological sites. The Conversation. Online at http://theconversation.com/how-virtual-reality-is-opening-up-some-of-the-worlds-most-inaccessible-archaeological-sites-88286.

13 Sheehy, Kieron; Garcia Carrizosa, Helena; Rix, Jonathan; Seale, Jane and Hayhoe, Simon (2019). Inclusive museums and augmented reality. Affordances, participation, ethics and fun. The International Journal of the Inclusive Museum.

14 MoMAR Gallery (2017). Webpage. Online at http://momar.gallery/ (accessed 13/02/2020).

3D printing can also complement the use of simulations and digital learning environments.[15] Websites such as Thingiverse allow the free and open sharing of user-created digital design files which can be used to 3D print a wide range of objects.[16] This is likely to help learners who prefer hands-on learning. For example, it is possible to imagine chemistry students in the future being able to download and print physical models of chemical structures, such as molecules. Similarly, someone seeking to learn more about architecture could recreate 3D models of buildings from the comfort of their own home, instead of having to visit buildings in person or rely on photos.

Gamification

Game-based learning or gamification is learning in a more engaging format, with stimulators and scenarios allowing users to be embedded in game-like situations.[17] Gamification is a growing field of online learning that is pedagogically changing how learn - the primary aim is to create incentives or goals for people to learn.[18]

This type of learning has long occurred in offline settings, for example, getting a gold star or a stamp for achieving good exam results at school. Nonetheless, the rise of online learning is creating opportunities for new and more sophisticated gamification.

Duolingo - the popular language-learning website and app - makes extensive use of gamification techniques. The platform allows users to earn virtual coins and unlock new levels as language skills are improved.[19]

It is important to remember, however, that gamification might not be suitable for everyone.[20] This type of learning can reduce the involvement of other learners and the potential for social interaction - that is can be crucial to encouraging students to continue learning. For those who are less motivated or receive less structured educational support at home - where parents might be unable to encourage children to keep playing - relying on these education methods could have a detrimental effect.[21]

Some gamified apps aim to bring children and parents together, such as those that include story-telling for early years literacy.[22] This is an exemplar of blended informal learning opportunities, where children read aloud to their parents as well as edit and choose content online to learn.

The development of 'e-tivities', activities that enable active and participative online learning by individuals and groups, are an important new form of online gamified learning.[23] These learning experiences have developed out of text-based computer-mediated environments, such as bulletin boards or forums, and are often available for free or at a low cost.[24] These might be created peer-to-peer or created by teachers. One of the key pedagogical differences of these new online activities is that they "promote a learner-centred, task or problem-based approach to online learning", thereby moving "away from content-centric design".[25]

In some places, gamification is helping to semi-formalise previously informal types of learning, such as literacy skills (see Case Study 2).

CASE STUDY 2: NAVIGO FOR EARLY YEARS LITERACY

Navigo, an app co-designed by the Institute of Education as part of the European Commission's Horizon 2020 programme, helps parents to improve their children's early literacy.[26]

15 A process used to fabricate three dimensional objects based on the digitally controlled deposition of successive layers of material until a final structure is created. It is also known as additive manufacturing. For more: Ambrosi, A., & Pumera, M. (2016). 3D-printing technologies for electrochemical applications. Chemical Society Reviews, 45(10), 2740-2755.
16 Thingiverse (2020). Webpage.Online at https://www.thingiverse.com/ (accessed 13/02/2020).
17 The Department for Education (2016) Review of the online learning and artificial intelligence education market, p.27.
18 EdX (2020), Gamification Courses. Webpage. Online at https://www.edx.org/learn/gamification (accessed 13/02/2020).
19 TED-Ed (2020). Webpage. Online at https://ed.ted.com/ (accessed 13/02/2020).
20 Jacob, B. A. (2016). The opportunities and challenges of digital learning. Retrieved March, 20, 2019.
21 Ibid.
22 Kucirkova, N., Sheehy, K., and Messer, D. (2015) A Vygotskian perspective on parent–child talk during iPad story sharing. Journal of Research in Reading, 38: 428–441.
23 Gilly Salmon (2013), E-tivities: The Key to Active Online Learning, 2nd edition, Routledge, 2013.
24 Ibid., p.9.
25 Ibid., p. 7.
26 Institute of Education (2019). App co-designed by IOE researchers recognised by the Department for Education. Online at https://www.ucl.ac.uk/ioe/news/2019/dec/app-co-designed-ioe-researchers-recognised-department-education (accessed 13/02/2020).

The app aims to support novice readers to develop reading skills, as well as those that might find early years literacy more challenging, such as children with dyslexia or those learning English as a foreign language.[27] Navigo focuses mainly on accuracy, fluency and comprehension, by engaging with the personalised content and game activities. Crucially, it is designed to be engaging and exciting, to improve learning outcomes for children.

Collaborative learning and interactive learning communities

The internet has enabled more collaborative types of learning through interactive learning environments. Peer-to-peer communication - possible anywhere, at anytime - is being used to radically reshape learning processes. Interactive learning environments are enabling learners to exchange resources and to learn together in virtual forums. This may include chat bots mediating discussions, or even software that can analyse and summarise discussions.[28]

As Case Study 3 demonstrates, new types of collaboration and interaction through platforms has shifted the possibility for mentoring through aggregation. This has been enabled by new types of software, specific social media platforms, and online education portals.

CASE STUDY 3: FANFICTION.NET

Fanfiction - fiction written by a fan from the inspiration of a particular book, TV series or film - has been described by academics as an unexpected source for informal learning amongst young adults.[29] The world's largest repository - Fanction.net - has over 10 million users, with the median user 15.5 years old.

Researchers studying fan faction found users were not "only learning about writing; they're finding community, establishing identity, and exploring new trends that have not yet found mainstream acceptance."[30] Writers regularly explained that they had learned to write better though their fanfiction and some even said it had encouraged them to consider it writing professionally.[31]

The process of writing and editing fanfiction produced by others taught users important life lessons: to be more tolerant and willing to help others - many have received emotional support from other users.[32]

Unlike traditional learning patterns, where the more experienced teach those who are less experienced, on FanFiction.net the comments and feedback provided on writing samples were found to represent an informal peer mentoring network made up of comments. This had the effect of not just improving the writing skills of users but improving their teaching skills too.

Millions of users have created meaningful bonds from being connected via the website, and kept in touch by other mediums such as Skype. The authors of the study argue that this has also been a positive driver in preventing young people from feeling isolated.

The majority of students enrolled in higher education in the UK are now familiar with communication platforms, and feel comfortable using them day-to-day for their studies.[33] In professional contexts, social media also has the capacity to encourage informal learning through peer-to-peer communication or sharing resources and has been found to reduce professional isolation.

Communication platforms have been established specifically to link learners and teachers across the world. Skill Share, for example, is an online learning community that includes learning materials and

27 Ibid.
28 The Department for Education (2016) Review of the online learning and artificial intelligence education market, p.27.
29 Cecilia Aragon (2019), What I learned from studying billions of words of online fan fiction. MIT Technology Review
30 Ibid.
31 Ibid.
32 ibid.
33 David White, Nicola Warren, Sean Faughnan & Marion Manton (2010), Study of UK Online Learning. Department for Continuing Education, University of Oxford p.44

platforms the development of learning networks.[34] Currently, Skills Share offers 2000 classes and has 4 million students, across a variety of different subjects.

Adaptive education systems

Adaptive education systems deliver personalised resources and learning activities to respond to an individual's needs.[35] In the digital world, programmes can be adaptive without making use of AI. This might simply mean branching: learning systems preprogrammed to tailor experiences dependent on answers, e.g. "if student completes Question A, move them to Question B".[36]

CASE STUDY 4: SPOCS FOR TEACHER TRAINING IN DENMARK

Denmark has set a target to ensure all teachers of primary education have a bachelor's degree in the subject area in which they teach by 2020.[37] To help reach this target online adaptive education systems are being deployed for teacher training, in the form of SPOCs (Small Private Online Courses).[38] This is a system that "allows for students to create a personalised learning path on the basis of three components: a learner profile, a content model and an adaptation model".[39]

Algorithms are used in AI-enabled adaptive education to tailor activities and resources to individual learners. This might mean assessing the learners' strengths and weaknesses, responding with tailored materials to help them improve most effectively.[40] As a result, the programme can be truly adaptive to users, generating a completely personalised pathway unique to each user.[41] For example, KidAptive[42], an adaptive learning platform, helps education providers turn their data into actionable and meaningful insights for students and parents. This might include recommending the best content for students, for example.[43]

Through the use of algorithms to recommend tailored content based on previous activity and preferences, social media platforms when used for learning may also be considered adaptive education systems.[44] Platforms such as YouTube and Twitter that use machine learning[45] to recommend users specific videos or channels that might reinforce, encourage, or suggest learners relevant content to learn. This may work in informal ways: Erin Smith, founder of FacePrint - a piece of technology that tracks the development of Parkinson's through facial expressions - claims the inspiration came after watching a series of videos of Michael J Fox, an actor who developed Parkisons.[46]

It should be noted, though, that recommended content is part of a much larger system, traditionally associated with e-commerce and keeping users engaged - less with education.[47] Moreover, there has been some controversy around algorithms recommending content that might be harmful or dangerous to users.[48]

34 Skillshare (2020). Webpage. Online at https://www.skillshare.com/ (accessed 13/02/2020).
35 Scott N. Romaniuk (2018), Adaptive learning in the classroom and beyond. Education Technology.
36 Toby Baker and Laurie Smith with Nandra Anissa (2019) Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges. Nesta. p.11
37 Petersen, Christiansen, and Gynther, Changing Paradigms: From Schooling to Schools as Adaptive Recommendation Systems, Universal Journal of Educational Research 5(11): 2081-2091, 2017, p. 2086, online at http://www.hrpub.org/download/20171030/UJER25-19510175.pdf
38 Petersen, A. K., & Gundersen, P. (2019). Challenges in designing personalised learning paths in SPOCs. Designs for Learning, 11(1)
39 Ibid., p. 72-9.
40 The Department for Education (2016) Review of the online learning and artificial intelligence education market.
41 Toby Baker and Laurie Smith with Nandra Anissa (2019) Educ-AI-tion Rebooted? Exploring the future of artificial intelligence in schools and colleges. Nesta.(11).
42 Kidaptive (2020). Webpage. Online at https://www.kidaptive.com/ (accessed 13/02/2020)
43 https://www.kidaptive.com/use-cases/
44 Thomas Mcmullan (2018),YouTube's spending millions on how-to videos so you trust it again. Wired
45 A class of AI methods that take data samples as input and produce a mathematical model of the sample data. Instead of requiring explicit programming of this model, machine learning algorithms identify patterns in data to extract information that can be used to reproduce or predict the behaviour of the system they are trying to learn about. - Centre for Data Ethics and Innovation (2020), Review of Online Targeting, Available at: https://www.gov.uk/government/publications/cdei-review-of-online-targeting/online-targeting-final-report-and-recommendations#appendix-5-glossary
46 Amid Katwala (2019).A YouTube binge helped invent a new way to diagnose Parkinson's. Wired.
47 Khribi, M. K., Jemni, M., & Nasraoui, O. (2007, October). Toward a hybrid recommender system for e-learning personalization based on web usage mining techniques and information retrieval. In E-Learn: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education (pp. 6136-6145). Association for the Advancement of Computing in Education (AACE).
48 Thomas McMullan (2018). YouTube's spending millions on how-to videos so you trust it. Wired.; Alexis Madgrigal (2018). How YouTube's Algorithm Really Works… if you're not the average YouTube user. The Atlantic.

Intelligent tutoring systems

Intelligent tutoring systems systems are able to replicate one-to-one tutoring by providing immediate tailored instructions and feedback to learners without intervention from a human tutor.[49] This might include software that assesses the test results and assignments to provide feedback on grammar or identify topics where a learner is struggling. These systems have been made possible by the rise of big data analytics: statistical analysis of large data sets, in this case data such as a student's previous performance.

These tools tend to serve as a teaching aid, but they may also diagnose why students make specific errors. They may also provide specific aid to students who struggle with time management and organisation, helping them to improve their pre-class preparation and prevent them from falling behind.[50] Indeed, new systems such as ALEKS and UpLearn (see Case Study 5 and 6 respectively) tutor students online based on what they appear to know, filling the gaps accordingly.

CASE STUDY 5: ALEKS

ALEKS (Assessment and Learning in Knowledge Spaces) is an AI assessment and learning system which identifies what a student might 'know' and what it does not, thereby identifying where to fill the gaps.

The tool has been developed at New York University and California University by a team of software engineers, mathematicians and cognitive scientists. It claims to be the first to be able to map, at a granular level, where each student is within a course in terms of learning development and guide them through accordingly.

ALEKS uses adaptive questioning and years of data collection to determine what a student knows in real time and identify the topics they are most ready to learn. As the student works through a course, ALEKS "periodically reassesses the student to ensure that topics learned are also retained".[51]

A key benefit is that students are continually reassessed and that topics are only offered to students once ALEKS 'knows' the student is ready for it. This process can help to ensure that students are appropriately challenged, rather than frustrated or bored.[52]

Education system and governance

The rise of new online learning technologies are changing the education system and its governance. In some places, new technologies are actively being created in a way to overcome policy gaps - focusing on developing new types of technology that can deliver high quality, accessible learning opportunities. The European Commission 2020 Horizon programme is just one example, actively developing new infrastructure and integrated tools for personalized learning where there are market gaps.[53]

AI TEACHERS AND OPEN LEARNER MODELS

Artificial intelligence and big data collection is enabling teachers, education institutions and governments to manage learning in wholly new ways. In the formal education system, these technologies have created the potential for personalised learning pathways. Open Learner Models collect data relating to students or learners' attendance, performance and achievements, making this available to teachers or other learners.[54]

Big data can be processed using online or AI tools to highlight trends and predict learners learning pathways, e.g. whether a learner who struggles in a learning pathway will struggle in the next module. This is enhancing and potentially replacing some of the processes that a teacher might be expected to typically carry out (see Case Study 6).

49 The Department for Education (2016) Review of the online learning and artificial intelligence education market, p.27.
50 Jacob, B. A. (2016). The opportunities and challenges of digital learning. Retrieved March, 20, 2019.
51 ALEKS (2020). Webpage. Online at https://www.aleks.com/about_aleks/overview (accessed 13/02/2020).
52 Ibid.
53 The European Commission (2020) CORDIS. Online at https://cordis.europa.eu/project/id/731724 (accessed 13/02/2020)
54 The Department for Education (2016) Review of the online learning and artificial intelligence education market.

CASE STUDY 6: UPLEARN FOR A-LEVEL REVISION

UpLearn, an online platform for revision aimed at A-Level students, is a combination of adaptive education system, intelligent tutoring system as well as an open learner systems.

The programme analyses insights from students' strengths, weaknesses, and behaviour at a granular level. Based on these insights, UpLearn personalises the user's learning pathways, directing them to the most important lesson, quiz or activity for them to do next, until they reach a score of 90% in every topic.[55] The program will adapt to a students need, identifying weak spots and focusing on those, until a student "is achieving A* across every topic."[56] Further, it will also work to optimise a students time until an exam, ensuring their time is best used to their advantage.

CERTIFICATION (CREDIBILITY) QUANTIFYING YOUR ONLINE LEARNING

As opportunities to learn online grow, so does the appetite for accrediting and quantifying this type of learning (see Case Study 7).

CASE STUDY 7: DEGREED

Degreed is a lifelong learning platform that, among other functions, helps individuals to earn credentials from the online learning they carry out.[57] This allows an individual to combine recognition for their offline learning, such as a degree, with recognition for additional online learning activities, for example keeping track of the books or articles read or the videos you watch during your time online and categorising these into skills and credentials.

The application also helps individuals find the types of content they wish to learn faster, as well as providing users with certificates - at a cost - based on activity, behaviour and two references or endorsements.[58]

Certification of online learning, proving the completion and achievement of learning in more informal or non-traditional settings, may be advanced in future through blockchain technology.

In general, a blockchain is a distributed database that provides a public or semi-public record of digital transactions that is very difficult to alter.

MIT's Blockcerts project is already deploying this technology to aid the certification of online learning. One example of blockchain deployed in this way is the Blockcerts project from MIT.[59] Blockcerts is a blockchain-based standard that allows any user, including traditional and online-only, to access base code and develop their own software for issuing and verifying credentials.[60] This could provide a secure and interoperable way for MOOCs to trustlessly verify student accomplishments in online learning, making them more appealing as an alternative source of formal education.

Looking further ahead, the Open University is investigating the idea of a 'university of one'.[61] Instead of spending 3 years at a single university, a degree will be constructed from an 'a la carte' set of courses. Some of these modules would be undertaken through face to face tuition but others will be taught through blended or totally online means. Blockchain could help to enable this disaggregation and mixing of online learning with traditional face-to-face university instruction, through micro-accreditation of each individual course. They also see the transferability of skills could be facilitated through the accreditation of MOOCs enabled by blockchain technology.

NEW TECH AND INFRASTRUCTURE

Changes in our internet infrastructure will likely enable changes in the education system. The rollout of 5G networks, the next generation of wireless

55 Uplearn (2020). Website. Retrieved from https://uplearn.co.uk/ (accessed 13/02/2020).
56 Ibid.
57 https://www.youtube.com/watch?v=ofND0tbaVKk&feature=youtu.be
KaplanIncMedia (2013, September 13). Degreed | Demo Day [Video file]. Retrieved from https://www.youtube.com/watch?v=ofND0tbaVKk&feature=youtu.be
58 Degreed (2020). Website. Retrieved from https://degreed.com/ (accessed 13/02/2020).
59 Blockcerts (2020). Website. Retrieved from https://www.blockcerts.org/about.html (accessed 13/02/2020)
60 Alex Grech, Anthony F Camilleri, Andreia Inamorato Dos Santos (2017). Blockchain in Education. Publications Office of the European Union, p. 53.
61 Ibid., p. 66.

network technology, is one prominent example. 5G has the potential to offer faster data transfers, higher capacity and fewer delays in communication; all of which could be highly valuable to online learning.

This responsivity will enable applications and technologies that traditionally needed to be run on local hardware or via a WiFi network to be used in new scenarios, for example, allowing for the use of VR and AR as discussed above in new contexts. It may also boost online learning in parts of the country that receive 5G before fibre broadband, e.g. certain rural areas where it may be a more economical broadband solution.

It will also enable a much higher throughput of real time data collection and analysis, in e.g. the intelligent tutor systems above, allowing them to take in more datapoint and so be more personalised in real time.

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