The Value of Digital Assistants to the Department for Education

Introduction

The Department for Education is a governmental body and organisation "responsible for children's services and education, including early years, schools, higher and further education policy, apprenticeships and wider skills in England." (DfE, 2022). This paper argues that digital assistants could be valuable to them, by considering their needs, technology models, technology capabilities and costs.

Technology Adoption in Education

Current information system adoption models aim to explain and predict the adoption of technology in a variety of settings, including education (Granić, 2022) for predictive purposes. The 'Technology Acceptance Model' (Davis, 1989), or TAM, is one that is widely used today. It models 'technology adoption' as a consequence of 'behavioural intention'.

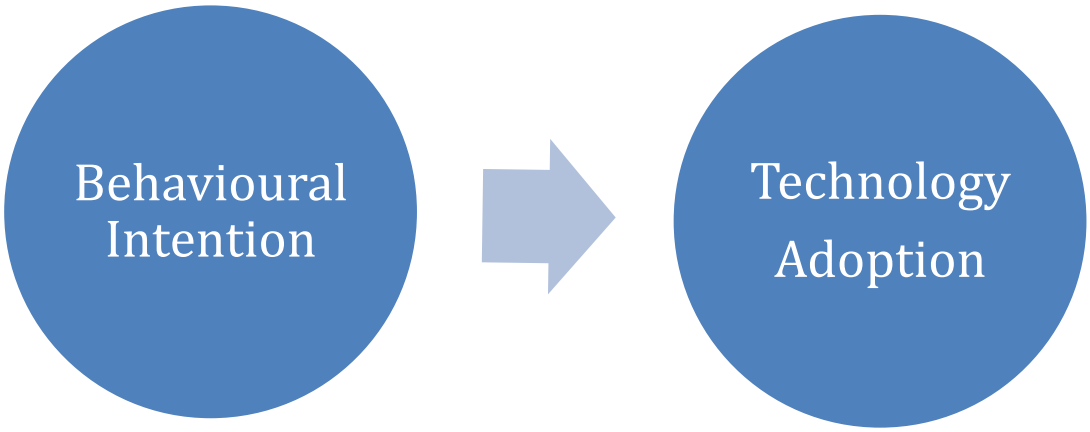

Figure 1. Technology Acceptance Model: Intention to Adoption

The TAM ontology goes further, and conceptualises behavioural intention as a consequence of perception; thus, providing a cognitive origin to technology adoption. Information processing in humans is modelled as the basis of information system adoption. TAM specifies the components of behavioural intention to be: ‘perceived usefulness’ and ‘perceived ease of use’ of technology (Davis, 1989).

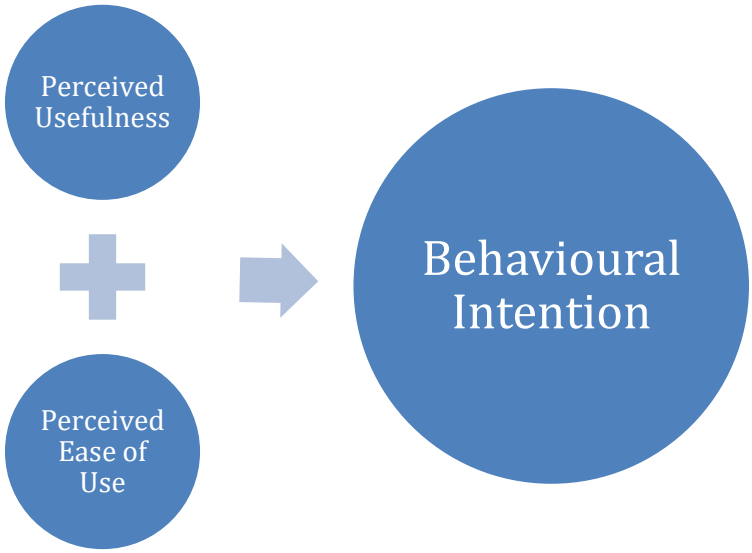

Figure 2. Technology Acceptance Model: Components of Intention

TAM provides a reasonable explanation for the educational technology adoption that took place during the Covid-19 pandemic. During this time, the use of remote education technology increased due to the needs of students to isolate (Ofqual, 2021; DfE, 2022). The consequential perceived usefulness of remote education methods resulted in the adoption of technology by educators. Students on the other hand, were found to spend less time learning overall (Ofqual, 2021). TAM prescribes that this problem was caused by technology being seen as too difficult or useless.

Despite efforts to understand the educational trends that took place during the Covid-19 pandemic; Ofqual (2021) note “There is much about learning during the

pandemic that remains unknown and under researched." Current methods were limited somehow, so a remedy to the problem has not yet been found. Educational recovery from this problem is a goal of the Department for Education (Ofsted, 2022). We can consider at least three different ways to recover:

i) By reducing perceived difficulty of educational technology

ii) By reducing perceived uselessness of educational technology

iii) By providing alternative research methodology for understanding the problem.

A technology that plays a part in educational recovery, is likely to be adopted by the Department of Education, according to TAM.

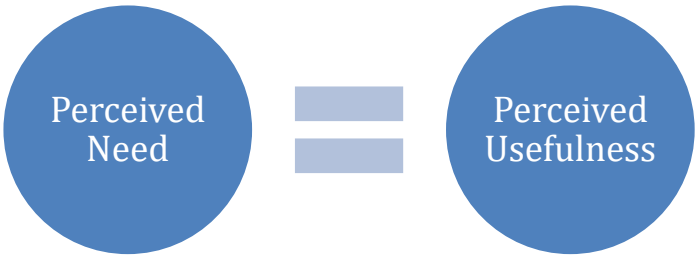

Figure 3. Technology Acceptance Model: Needs

Conversational Agents

A conversational agent or CA is a component of technology that is capable of conversation with a human (Laranjo et al., 2018), and can be considered a component of a digital assistant. Recent variations are built upon deep natural language machine learning models (Whade & Virgolin, 2022), and they may be accompanied by other expressive components such as avatars (Simonite, 2017; Whade & Virgolin, 2022) and personality (Allouch et al., 2021). Examples include

Alexa (Amazon, 2022) and ChatGPT (OpenAI, 2022). CAs can currently perform a range of tasks (Whade & Virgolin, 2022), and it's proposed that these can help with the educational recovery that the Department of Education seeks.

Since 1966, a class of CAs that mimic a real person with text, known as a chatbot; have been shown to be capable of therapeutic affects (Weizenbaum, 1966). Weizenbaum's 'Eliza' was a pattern-based chatbot that specialised in responding to speech with follow-up questions, and the questioning itself was found to be therapeutic.

If a CA could derive from this and act as an educational mentor, it would directly help with the educational recovery of students impacted by the covid-19 pandemic. Well-designed questions could alleviate stress and negative perceptions, and be used to gather information from students, as a data source for further educational advancements too. This role would make CA's good by TAM's standards. CA's are routinely deployed today to respond to FAQ's (Mendoza et al., 2022), which in combination with follow-up questions gives CA's a firm grounding as an educational tool.

Other perks of CAs to education include:

- Conversation itself can be stimulating (Whade & Virgolin, 2022).
- Some ability to converse is generally possible for everybody in education, and not perceived as difficult, or useless. This bypasses digital illiteracy problems that other technology creates.
- CA's have the ability to handle multiple requests at the same time, while a teacher cannot, which is useful for large classes. (Winkler & Söllner, 2018).

- CA's can provide a reduced-time-to-response (Radziwill, 2017), to students during obscure hours, or while a teacher is busy.
- CA's can provide educational scaffolding to reduce perceived difficulty of concepts (Winkler et al., 2020; Ueno & Miyazawa., 2017).
- CA's can provide recommendations and reminders (Mendoza et al., 2022).
- CA's can make use of other technological components to perform actions for students (Allouch et al., 2021)

Actual examples of CA's in education include Sara (Winkler et al., 2020), Teacherbot (Bayne, 2015), MathBot (Cai et al., 2021), and the University of Hong Kong's messaging app (Gonda & Chu, 2019).

Digital Social Innovation

Digital assistants could provide benefits to students and teachers not in educational recovery too, as a type of digital social innovation or DSI. The Department for Education provides guidance for numerous social issues relevant to schools that are worth addressing such as: safeguarding children (DfE, 2022), teacher's conduct (DfE, 2021) and student attendance (DfE, 2022). The innovation that a digital assistant provides is in communication.

Mendoza et al (2022) provide a communication model that makes use of a digital assistant as an intermediary between different personal relevant to education. In that model, personal are categorised into three groups: teachers, students and admin. Messages can then be sent back and forth between these groups, through the digital assistant.

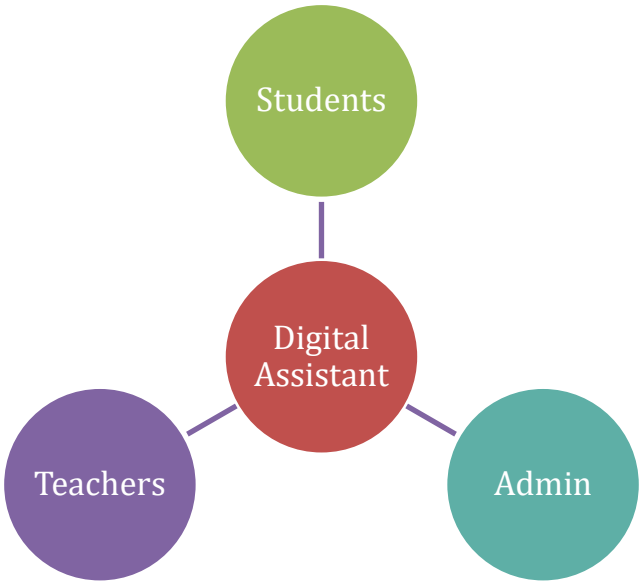

Figure 4 Mendoza et al. Communication Model

This model, in theory, could be developed further to include parents, psychologists, social workers, or any other roles that might need messages relayed between them. Whilst this is already possible thanks to current network technology, digital assistants provide an assistive layer to that technology.

The benefits of digital assistants over alternative communicative mediums include:

a) **Comfort**; voice and text user interfaces can be customised to be pleasant to use and even therapeutic, providing a non-commercial and safeguarded form of communication, with the aid of sociolinguists, social psychologists and IoT designers.

b) **Capability**; digital assistants can essentially provide an artificial intelligence to a network, with its own systematic protocols on top of the internet protocol suite, to match the protocols that good humans would use in response to language.

The disadvantages of digital assistants over alternative communicative mediums include:

a) **Intrusion**: The privacy, security and data protection policy would need to at least match the standards that already exist at schools, to objectively provide any other improvements.
b) **Cost**: An initial investment would be required before the technology and required infrastructure can be developed specifically for the national education of England.

Teaching Assistants

Traditionally, machine learning has been deployed for data analysis. Digital assistants have been designed to perform assessments (Parmar et al, 2022). Educators spend a lot of time marking work, so an intermediary that can do that is assistive to teachers.

An AI with a knowledge base could provide other benefits. Whade & Viroglin (2022) give examples of chatbots capable of information retrieval. The ability to answer specific types of questions such as admin-related, or content-related questions, would save educational staff time too, as they wouldn't need to repeat themselves.

Another type of knowledge that would boost a digital assistants' capabilities is the knowledge of goals. The awareness of the goal of an assignment, and the goal of a curriculum, along with knowledge of subject content would provide a foundation to procedurally generated tutoring. Intelligent tutoring systems (Allouch et al., 2021; Paladines & Ramirez, 2020) already exist, but an awareness of curriculum and assignment goals would provide additional configuration to the digital assistant. The

addition of content and goals to a digital assistant per curriculum, ensures that the same digital assistant can be used whenever and wherever that curriculum is used. An example of an engine capable of creating procedurally generated explanations is Wolfram Alpha (WolframAlpha, 2022).

Assistive communicative protocols that digital assistants would require include:

- Chit chat (Zhang et al., 2018) protocols to improve moods, gather information or fill time.
- Retrieval protocols to handle information retrieval.
- Relay protocols to handle information relaying.
- Safeguard protocols to handle profane, emotionally elevated, or disturbing inputs.
- Cryptographic protocols to provide a level of privacy, security and protection.
- Broadcast protocols for alerts.
- Sharing protocols for data sharing

Adoption Cost

The growth of technology companies has given rise to software as a service, or SaaS, that specialises in digital assistants. Example prices for these services as of December 2022 are given below:

Table 1 Price comparison of digital assistants from SaaS providers

Service Name	Price per API request	Price per Second of Audio	Price per Monthly User	Price per Monthly Device
Diagflow (Google Cloud, 2022)	$0.007	$0.001	-	-
Watson Assistant (IBM, 2022)	-	-	$1.40	-
Alexa (Amazon, 2022)	-	-	$3	$7

Services that charge per user per month, provide an opportunity to predict the costs of a typical school in England. For example, Amazon's Alexa would cost about £36,000 a year for a school with 1000 users, and additional £84,000 a year if each user has their own device, assuming $1 = £1. There would also be an initial hardware purchase fee too.

Hardware costs would be avoidable if the digital assistant was developed for household technology initially, such as tablets and computers. That would make the initial adoption of the technology, much cheaper. As households evolve, the assistant could make use of other IoT devices too.

If the price per user per month for a digital assistant could match Amazon's price of £3, then the cost of adopting a digital assistant per school, which is about £36,000, is about the same per year as the average teachers wage of £42,000 (DfE, 2021). The cost of adopting a digital assistant would therefore be reasonable, if it could match 40 hours per work a week that a teacher would do.

The digital assistant could meet the target of 40 hours per week by saving staff time or providing time to students. For a school with 40 staff, that could amount to saving each member of staff around one hour per work doing preparation,

assessment, or administrative tasks. Alternatively, for a school with 10 classes, then 4 hours of tutoring per class would meet the target. For a class of 20 students, a human tutor with a 4-hour span, could only provide 12 minutes of personal time to each student, whilst a digital assistant could provide 4 hours of personal tutoring to each student at the same time.

There are about 24,000 schools in England (DfE, 2022), so the development of a digital assistant that meets the above target, is effectively equal to 24,000 members of staff. Training 24,000 staff costs those staff around £216,000,000 for a one-year training course at university. For the 9,000,000 students currently in education (DfE, 2021), that amounts to around £2.50 per student. This would be a reasonable budget for the development of digital assistants for education.

Currently the government spend about £1,200 per student per year (UK Parliament, 2021). If the cost of a digital assistant matches the price of Alexa at £3 per user per month, then it would cost each user around £36 per year. There are around 1,000,000 staff in schools (DfE, 2021), so along with the 9,000,000 students, an annual fee of around £36,000,000 would be required. That's the same cost as putting 4,000 people per year through a one-year university course. The cost per student per year would effectively increase by £40 with the use of a digital assistant at Amazon's rates.

In 2021, for the 44,000 new teachers that started work, and around 36,000 teachers stopped working (DfE, 2021). The additional workforce was 25% of the those trained. This is unlikely to change unless conditions at schools are improved. Consequently, the annual budget of £36,000,000 per year would only increase the number of teachers by 25% of the 4000 newly trained teachers, or 1000 newly

trained teachers. It would then take 24 years to provide one additional teacher per school, to match what a digital assistant could do in one year.

A national teachers strike is due in January 2023 (BBC News, 2022), and a 1% increase in 450,000 teachers wages that average £42,000 (DfE, 2021), would cost about £189,000,000 per year. Putting £36,000,000 per year towards digital assistants is cost effective, because it reduces teachers stress and the need for pay rises, by decreasing teachers' hours. and it's likely that in 24 years' time, digital assistants would provide the workforce of more than 24,000 teachers, as the technology improves, surpassing alternative spending options.

Digital Assistants at Schools

During the development of a digital assistant, great care needs to go towards meeting ethical requirements and expectations. Issues such as data protection, privacy and security can be handled in the same way that current school policies dictate the use of the internet and internal websites. The digital assistant application should be non-compulsory for homes to avoid any controversy for sceptics, but obviously be available for those that would like the service.

Additional care needs to be given to the fact that the digital assistant may be highly trustable to students, so it essential that the digital assistant is able to recognise digital irresponsibility and teach upon it. This is much safer than students learning privacy lessons through alternative websites and software.

References

Allouch, M., Azaria, A. & Azoulay, R. (2021) Conversational Agents: Goals, Technologies, Vision and Challenges. *Sensors* 21(24): 8448. DOI: https://doi.org/10.3390/s21248448 [Accessed 06 December 2022].

Amazon. (2022) Alexa for Business pricing. Available from: https://aws.amazon.com/alexaforbusiness/pricing/ [Accessed 11 December 2022].
Amazon. (2022) What is Alexa?. Available from: https://developer.amazon.com/en-GB/alexa [Accessed 06 December 2022].

Bayne, S. (2015) Teacherbot: interventions in automated teaching. *Teaching in Higher Education* 20(4): 455-467. DOI: https://doi.org/10.1080/13562517.2015.1020783 [Accessed 07 December 2022].

Cai, W., Grossman, J., Lin, Z., Sheng, H., Wei, J., Williams, J. & Goel, S. (2021) Bandit algorithms to personalise educational chatbots. *Machine Learning 110(9): 2389-2418.* DOI: https://doi.org/10.1007/s10994-021-05983-y [Accessed 07 December 2022].

Davis, F. (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly* 13(3): 319-340. DOI: https://doi.org/10.2307/249008 [Accessed 04 December 2022].

Department for Education. (2021) *Guidance: Teachers' standards*. Available from: https://www.gov.uk/government/publications/teachers-standards [Accessed 10 December 2022].

Department for Education. (2021) *Reporting Year 2021 School workforce in England*. Available from: https://explore-education-statistics.service.gov.uk/find-statistics/school-workforce-in-england [Accessed 11 December 2022].

Department for Education. (2022) About us. Available from: https://www.gov.uk/government/organisations/department-for-education/about [Accessed 10 December 2022].

Department for Education. (2022) *Academic Year 2021/22 Schools, pupils and their characteristics*. Available from: https://explore-education-statistics.service.gov.uk/find-statistics/school-pupils-and-their-characteristics [Accessed 11 December 2022].

Department for Education. (2022) *Education technology for remote teaching Research Report*. Available from: https://www.gov.uk/government/publications/education-technology-for-remote-teaching [Accessed 05 December 2022].

Department for Education. (2022) *Guidance: Working together to improve school attendance*. Available from: https://www.gov.uk/government/publications/teachers-standards [Accessed 10 December 2022].

Department for Education. (2022) How we're making teacher training better and more accessible. Available from: https://educationhub.blog.gov.uk/2022/09/29/how-were-making-teacher-training-better-and-more-accessible/ [Accessed 11 December 2022].

Department for Education. (2022) *Statutory guidance: Working together to safeguard children*. Available from: https://www.gov.uk/government/publications/working-together-to-safeguard-children--2 [Accessed 10 December 2022].

Ferland, L. & Koutstaal, W. (2020) 'How's Your Day Look? The (Un)Expected Sociolinguistic Effects of User Modelling in a Conversational Agent', *CHI EA '20: Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*. Honolulu, Hawai'i: 25-30 April. New York: Association for Computing Machinery. DOI: https://doi.org/10.1145/3334480.3375227 [Accessed 07 December 2022].

Gonda, D. & Chu, B. (2019) 'Chatbot as a learning resource? Creating conversational bots as a supplement for teaching assistant training course', 2019 IEEE International Conference on Engineering, Technology and Education (TALE). Yogyakarta, Indonesia: 10-13 December. New York: IEEE. 1-5. DOI: https://doi.org/*10.1109/TALE48000.2019.9225974* [Accessed 07 December 2022].

Google Cloud. (2022) Diagflow. Available from: https://cloud.google.com/dialogflow [Accessed 11 December 2022].

Google Cloud. (2022) Diagflow pricing. Available from: https://cloud.google.com/dialogflow/pricing [Accessed 11 December 2022].

Granić, A. (2022) Educational Technology Adoption: A systematic review. *Education and Information Technologies* 27(7): 9725–9744. DOI: https://doi.org/10.1007/s10639-022-10951-7 [Accessed 04 December 2022].

IBM. (2022) Watson Assistant pricing Start building exceptional customer experiences today. Available from: https://www.ibm.com/products/watson-assistant/pricing [Accessed 11 December 2022].

Laranjo, L., Dunn, A., Tong, H., Kocaballi, A., Chen, J., Bashir, R., Surian, D., Gallego, B., Magrabi, F., Lau, A. & Coiera, E. (2018) Conversational agents in healthcare: a systematic review. *Journal of the American Medical Informatics Association* 25(9): 1248-1258. DOI: https://doi.org/10.1093/jamia/ocy072 [Accessed 06 December 2022].

Mendoza, S., Sánchez-Adame, L., Urquiza-Yllescas, J., González-Beltrán, B. & Decouchant, D. (2022) A Model to Develop Chatbots for Assisting the Teaching and Learning Process. *Sensors* 22(15): 5532. DOI: https://doi.org/10.3390/s22155532 [Accessed 07 December 2022].

Ofqual. (2021) *Learning during the pandemic: review of research from England*. Available from: https://www.gov.uk/government/publications/learning-during-the-pandemic/learning-during-the-pandemic-review-of-research-from-england [Accessed 04 December 2022].

Ofsted. (2022) *Education recovery in schools: spring 2022*. Available from: https://www.gov.uk/government/publications/education-recovery-in-schools-spring-2022/education-recovery-in-schools-spring-2022 [Accessed 05 December 2022].

OpenAI. (2022) ChatGPT: Optimizing Language Models for Dialogue. Available from: https://openai.com/blog/chatgpt/ [Accessed 06 December 2022].

Paladines, J., & Ramirez, J. (2020) A Systematic Literature Review of Intelligent Tutoring Systems With Dialogue in Natural Language. *IEEE Access 8: 164246-164267.* DOI: https://doi.org/10.1109/ACCESS.2020.3021383 [Accessed 07 December 2022].

Parmer, P., Ryu, J., Pandya, S., Sedoc, J. & Agarwal, S. (2022) Health-focused conversational agents in person centered care: a review of apps. *npj Digital Medicine* 5(21): 1-9. DOI: https://doi.org/10.1038/s41746-022-00560-6 [Accessed 06 December 2022].

Radziwill, N. & Benton, M. (2017) *Evaluating Quality of Chatbots and Intelligent Conversational Agents*. DOI: https://doi.org/10.48550/arXiv.1704.04579 [Accessed 04 December 2022].

Ueno, M., & Miyazawa, Y. (2017) IRT-Based Adaptive Hints to Scaffold Learning in Programming*. IEEE Access 11(4): 415-428.* DOI: https://doi.org/10.1109/TLT.2017.2741960 [Accessed 07 December 2022].

UK Parliament. (2021) *Education spending in the UK*. Available from: https://commonslibrary.parliament.uk/research-briefings/sn01078/ [Accessed 11 December 2022].

Weizenbaum, J. (1966). ELIZA—a computer program for the study of natural language communication between man and machine. *Communications of the ACM*, *9*(1), 36-45. DOI: https://doi.org/10.1145/365153.365168 [Accessed 06 December 2022].

Wahde, M. & Virgolin, M. (2022) *Conversational Agents: Theory and Applications*. DOI: https://doi.org/10.48550/arXiv.2202.03164 [Accessed 07 December 2022].

Winkler, R., Hobert, S., Salovaara, A., Söllner, M. & Leimester, J (2020) 'Sara, the Lecturer: Improving Learning in Online Education with a Scaffolding-Based Conversational Agent', *CHI EA '20: Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*. Honolulu, Hawai'i: 25-30 April. New York:

Association for Computing Machinery. DOI: https://doi.org/10.1145/3313831.3376781 [Accessed 07 December 2022].

Winkler, R. & Söllner, M. (2018) 'Unleashing the Potential of Chatbots in Education: A State-Of-The-Art Analysis', *Academy of the Management Proceedings.* Chicago: 10-14 August. New York, Academy of Management. DOI: https://doi.org/10.5465/AMBPP.2018.15903abstract [Accessed 07 December 2022].

Wolfram, S. (2019) What We've Built Is a Computational Language (and That's Very Important!). Available from: https://writings.stephenwolfram.com/2019/05/what-weve-built-is-a-computational-language-and-thats-very-important/ [Accessed 11 December 2022].

WolframAlpha. (2022) Example for Step-by-Step Proofs. Available from: https://www.wolframalpha.com/examples/pro-features/step-by-step-solutions/step-by-step-proofs [Accessed 11 December 2022].

Zhang, S., Dinan, E., Urbanek, J., Szlam, A., Keila, D. & Weston, J. (2018) *Personalizing Dialogue Agents: I have a dog, do you have pets too?.* DOI: https://doi.org/10.48550/arXiv.1801.07243 [Accessed 07 December 2022].