Digitization of Elementary School Science Learning In The Industrial Era 4.0

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ARTICLE INFO	ABSTRACT
	Facing this era of globalization, motivation alone is not enough, but there must be a concrete form and a hard effort. One of them is the use of technology, as for subjects related to technology, namely Science. This is because it has aspects of product, process, scientific attitude, and application. In the application aspect is the application of abstract concepts in concrete form in the form of technology. So that it leads to the development and utilization of technology with the aim of improving 4C skills. However, in reality there is still little research that explains how to digitize elementary science learning in the industrial era 4.0. So the purpose of this research is to provide an overview of digital-based elementary science learning innovations in the industrial revolution 4.0 era, in the form of strategies, media and assessment of elementary science learning. Then this research uses the literature study method, while the results of this study describe the effective digitization of elementary science learning using E-learning, personalized learning, flexible delivery, practical application, flexible exams, student ownership, and continuous feedback mechanisms. So that the researchers provide further research recommendations to describe the digitalization of science learning more broadly, including the curriculum to digital devices, as a support for the implementation of elementary science learning in the industrial era 4.0.

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1. INTRODUCTION

Education and learning cannot be separated from the development of information and technology that has become an important part. There is now an industrial transformation that opens up new ways to build customized systems, using flexible machines and optimized resources (Yoshino et al., 2020). It was also announced in 2016, by the World Economic Forum stating that humanity has entered the era of

Industry 4.0 (Kester et al., 2019). These latest concepts include Computational Intelligence, Internet of Things, Industrial Internet, Big Data, Cloud-based Manufacturing, and Smart Manufacturing, which can forecast upcoming digital-enabled production (Cropley, 2020). Based on these concepts, making the state of learning now requires the use of technology in it, which is not limited to space and time (Singhal et al., 2020).

Learning in era 4.0 aligns people and technology to give birth to new knowledge by connecting students and facilitators who aim to build a global education ecosystem, with forms of learning that put students at the core of the learning ecosystem and empower them to design their own learning journeys (Koul & Nayar, 2021). In addition, students can choose their educational programs, pedagogy, learning experiences and equipment in line with their specific needs and tendencies towards a learning curve. So as to create a conducive learning environment, an independent learning environment is needed. (Oktavian & Aldya, 2020). The use of the internet is a form of effort to improve digital technology, thus making a big challenge, namely the application of digital technology to answer the challenges of learning today. One of them is the use of technology, as for subjects related to technology, namely natural science.

This is because the learning of Natural Sciences not only emphasizes the mastery of knowledge, but also emphasizes the discovery process, so that Natural Sciences can help students understand the surrounding nature (Handayani & Jumadi, 2021). In addition, Natural Knowledge also has several aspects, namely products, processes, scientific attitudes, and applications.

In the application aspect is the application of abstract concepts in concrete forms in the form of technology. By assisting technological sophistication can help students understand the environment of students, so that the message on natural science learning that is initially still abstract can be summarized with technology assisted, so that the essence of natural science learning can be conveyed to students easily. In addition, it can lead to the development and utilization of technology with the aim of improving 4C skills (critical thinking, creative, collaborative, and commnicative)(Jayanti S., 2019).

Apart from this, there are several studies that have applied the concept of digitalization to their learning systems, namely in research. Ilomäki & Lakkala (2018) Demonstrating digital school innovation models helps teachers reflect on and improve their own learning practices. This is also explained by research Neumann & Waight (2020) digitalization of science education will create a digital ecology that can help improve science teaching, learning, and assessment so that science education can be evenly distributed to a new level. Then research Kaarakainen & Saikkonen (2021)

The use of digital technology has been implemented in elementary schools in Finnish learning that shows digital skills, age, self-efficacy can increase the use of technology in teaching. So based on some of the research that was anointed, it is very important in applying digitalization to the elementary school learning system. But the three studies, have not provided an overview of the digitization of elementary school natural science learning, so this research aims to provide an overview of the innovation of digital-based elementary school natural science learning in the era of industrial revolution 4.0, in the form of strategies, media and assessment of elementary school natural science learning. This is intended to improve pedagogical abilities and knowledge practices in Indonesia.

2. METHODS

The This study uses literature review. According to Creswell (Denney & Tewksbury, 2013) A literature review is a comprehensive overview of previous research on a particular topic. In identifying relevant studies, a systematic search was conducted on a database, beginning in May 2021. The selection of relevant articles is done in several steps, namely journal searches conducted on electronic databases namely Science Direct, Taylor & Francis, Wiley, Sage, Springer and journals sinta 1 and 2. So this research traces from various articles used using the keywords "digitization of natural science learning", and "era of industrial revolution 4.0". The articles selected in this review must meet the criteria of the topics discussed, using qualitative and quantitative data, and these articles must meet the maximum criteria of the last 10 years, namely 2011-2021.

2.1. Eligibility criteria

Abstracts are analyzed, evaluated for relevance according to the main focus of the review. So this article focuses on (1) the digitization of natural science learning, (2) the era of industrial revolution 4.0. So that only journal articles and proceedings are included, while books, dissertations and the like, research reports, papers and journals that are not published in the selected database, are not used and issued in this article.

2.2. Article selection

Based on the database search results generated 105, but after being evaluated based on its abstract, some articles are irrelevant to the keywords set earlier. Then 60 articles were reevaluated in full and thoroughly. So that produces articles used in this study as many as 33 that have been in accordance with the specified criteria. As for the picture as follows:
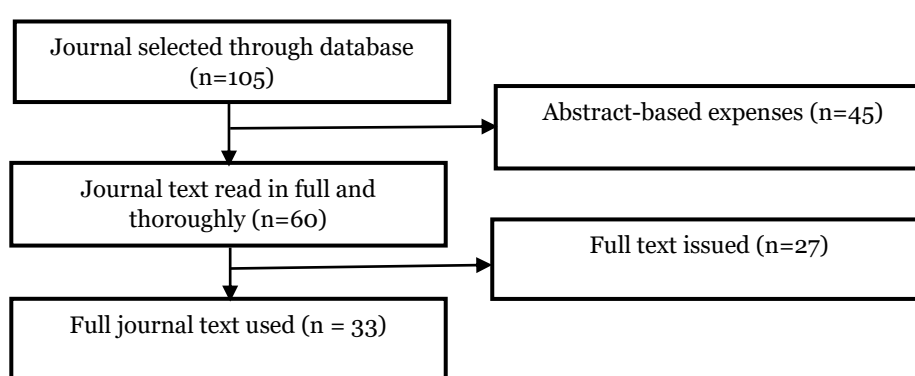

Figure 1. Stages of article selection

3.   FINDINGS AND DISCUSSION

The In this section presents the results and discussions of the research studied. The study provides an overview related to the digitization of IPA learning that can be implemented in elementary schools in the era of industrial revolution 4.0. The results of the literature review of 33 articles can be seen in table 1 below:

Table 1. The results of research articles that can be implemented in the learning of Elementary School Natural Sciences in the Era of the Industrial Revolution 4.0.

Author / Year	Title	Source Type	Method	Level of Education	Database	Research Focus
Koul & Nayar, 2021	The Holistic Learning Educational Ecosystem: A Classroom 4.0 Perspective	Journal	Review Literature	Common	Wiley	Holistic Learning, Perspective 4.0
Firman syah & Minan dar, 2021	The Use of Madrasah E-Learning For Online Learning During The Covid-19 Pandemic	Journal	Qualitative	High School	Al-Ishlah Sinta 2	Online Learning During the Covid-19 Pandemic
Kacetl	Reflection on	Proceedi	Semi-	University	ScienceDi	Blended

& Semradova, 2020.	Blended Learning and E-Learning - Case Study	ng	Structured Interviews		rect	Learning E-Learning
Lalitha & Sreeja, 2020	Personalised Self-Directed Learning Recommendation System	Proceeding	Qualitative	Common	ScienceDirect	Self-Directed Learning
Dwijonagoro & Suparno, 2019	Pranatacara Learning: Modeling, Mind Mapping, E-Learning, or Hybrid Learning?	Journal	Experiment	University	Cakrawala Pendidikan Sinta 2	E-Learning Modeling Mind Mapping Hybrid Learning
Sole & Wilujeng, 2013	Pengaruh Implementasi The 4-E Learning Cycle Terhadap Pengetahuan, Keterampilan Proses Dasar, dan Sikap Ilmiah IPA Siswa SD Kererobbo	Journal	Experiment	Primary school	Jurnal Prima Edukasia Sinta 2	4-E Learning Cycle
Setiaji & Dinata, 2020.	Analisis Kesiapan Mahasiswa Jurusan Pendidikan Fisika Menggunakan E-Learning dalam Situasi Pandemi Covid-19	Journal	Survey	University	Jurnal Inovasi Pendidikan IPA Sinta 2	E-Learning
Atmojo Et Al., 2020	The Level Of Self-Regulated Learning And Self-Awareness In Science Learning In The Covid-19 Pandemic Era	Journal	Experiment	University	Jurnal Pendidikan IPA Indonesia Sinta 1	Self-Regulated Learning Self-Awareness Science Learning
Wijayanti & Basyar, 2016	The Development Of Thematic-Integrated E-Portfolio Media Web Blog Based To Increase The Scientific Literacy of Elementary Teacher Education Program's Student	Journal	Rnd	University	Jurnal Pendidikan IPA Indonesia Sinta 1	Media E-Portfolio Web Blog Based Scientific Literacy

Supar mining sih, 2016	Pengaruh Strategi Pembelajaran Pailkem dengan Media Animasi Terhadap Hasil Belajar IPA Siswa Kelas IV SDN 3 Kedungbanteng Tahun Ajaran 2015/2016.	Journal	Experiment	Primary school	Premiere Educandum Sinta 2	Animation Media Science of Nature
Safaru ddin Et Al., 2020	The Effect of PjBL with WBL Media And Cognitive Style on Students' Understanding and Science-Integrated Concept Application	Journal	Experiment	University	Jurnal Pendidikan IPA Indonesia	PJBL Media WBL
Yahya, 2014	Model Pembelajaran Berbasis Proyek Berbantuan Media Kultur Jaringan Untuk Meningkatkan Aktivitas dan Kreativitas Siswa Kelas XII IPA 2 SMA Negeri 1 Bangsri	Journal	PTK	High School	Jurnal Pendidikan IPA Sinta 1	PJBL Science of Nature
F. Fatima h, 2014	Pengembangan Science Comic Berbasis Problem Based Learning Sebagai Media Pembelajaran Pada Tema Bunyi dan Pendengaran Untuk Siswa SMP	Journal	Rnd	Common	Jurnal Pendidikan IPA Sinta 1	Science Comic Science of Nature
Mukti, 2019	Pengembangan Media Pembelajaran Augmented Reality (AR) Di Kelas V MI Wahid Hasyim	Journal	Rnd	Primary school	ELEMEN TARY: Islamic Teacher Journal Sinta 2	Augmented Reality (Ar)

Pujiast uti & Haryad i, 2020	The Use of Augmented Reality Blended Learning For Improving Understanding of Food Security In Universitas Sultan Ageng Tirtayasa: A Case Study	Journal	Experiment	University	Jurnal Pendidika n IPA Sinta 1	Augmented Reality Blended Learning
Syawal udin Et Al., 2019	Enhancing Elementary School Students' Abstract Reasoning in Science Learning Through Augmented Reality-Based Interactive Multimedia	Journal	PTK	Primary school	Jurnal Pendidika n IPA Sinta 1	Augmented Reality-Based Interactive Multimedia
Qumill aila Et Al., 2015	Pengembangan Augmented Reality Versi Android Sebagai Media Pembelajaran Sistem Ekskresi Manusia	Journal	RnD	High School	Jurnal Cakrawal a Pendidika n	Augmented Reality Versi Android
Saputr a Et Al., 2020	The Development of Learning Model Through Video Documentary To Improve Environmental Knowledge of Coastal Residents of Palopo City, Indonesia	Journal	RnD	Common	Jurnal Pendidika n IPA Indonesia	Learning Model Through Video Documentary
Tvenge Et Al., 2020	Added Value of A Virtual Approach To Simulation-Based Learning in A Manufacturing Learning Factory	Journal	Literature Review	Common	ScienceDi rect	Virtual Approach
Kerstin g Et Al., 2021	Exploring Participant Engagement During An Astrophysics Virtual Reality Experience at A Science Festival	Journal	Literature Review	Common	Tailor&Fr ancis	Virtual Reality

Wu Et Al., 2021	Integrating Spherical Video-Based Virtual Reality Into Elementary School Students' Scientific Inquiry Instruction: Effects on Their Problem-Solving Performance	Journal	Experiment	Primary school	Tailor&Francis	Integrating Spherical Video-Based Virtual Reality
Wang Et Al., 2019	Iterative User and Expert Feedback in The Design of An Educational Virtual Reality Biology Game	Journal	Qualitative	Common	Tailor&Francis	Virtual Reality Biology Game
Santamaría-Cárdaba, 2020	Families, Experiments, and Nature: Learning Science Through Project-Based Learning	Journal	Qualitative	Primary school	Wiley	Project-Based Learning Learning Science
Beier Et Al., 2019	The Effect of Authentic Project-Based Learning on Attitudes and Career Aspirations in STEM	Journal	Experiment	University	Wiley	Project-Based Learning
Craig & Marshall, 2019	Effect of Project-Based Learning on High School Students' State-Mandated, Standardized Math and Science Exam Performance	Journal	Qualitative	High School	Wiley	Project-Based Learning
Hussain & Jaeger, 2018	LMS-Supported PBL Assessment in An Undergraduate Engineering Program—Case Study	Journal	Case study	University	Wiley	LMS-Supported PBL Assessment
Rahman Talukder Et Al., 2021	Primary Science Teaching in Bangladesh: A Critical Analysis of The Role of The Dped Program to Improve The Quality of	Journal	Quantitative	University	ScienceDirect	Science Teaching

	Learning in Science Teaching					
Granberg Et Al., 2021	A Case Study of A Formative Assessment Practice and The Effects on Students' Self-Regulated Learning	Journal	Qualitative	Primary school	ScienceDirect	Formative Assessment
Chien & Wu, 2020	Examining Influences of Science Teachers' Practices and Beliefs About Technology-Based Assessment on Students' Performances	Journal	Quantitative	Junior High School, High School	ScienceDirect	Technology-Based Assessment
Chang Et Al., 2020	Impacts of Augmented Reality and A Digital Game On Students' Science Learning With Reflection Prompts in Multimedia Learning	Journal	Experiment	Primary school	Springer	Augmented Reality A Digital Game Science Learning
Cannata et al., 2019	Building Student Ownership and Responsibility: Examining Student Outcomes From A Research-Practice Partnership	Journal	Sequential Mixed Methods	Common	Tailor&Francis	Student Ownership
Chism & Wilkins, 2018	Student Ownership for Blended Physical Education	Journal	Quantitative	High School	Tailor&Francis	Student Ownership Blended Learning
Chan et al., 2014	Beyond Involvement: Promoting Student Ownership of Learning in Classrooms	Journal	Literatur Review	Common	Sage	Ownership of Learning in Classrooms

Based on 33 research articles studied, providing information related to the digitization of Natural Science learning that can be implemented in elementary schools in the era of industrial revolution 40 is characterized by virtual collaboration, technological convergence, global connectivity and online communities is a change in the scope of learning (Koul & Nayar, 2021; Zawacki-Richter, 2021).

In the learning of Natural Sciences, there are various efforts made by educators in digitizing the natural science learning process in elementary school classes in the industrial era 4.0, in the hopes of providing opportunities for students to learn at different times and places. This can be achieved if the learning of Natural Sciences can apply some efforts (Koul & Nayar, 2021) such as the use of E-learning, personalized learning, flexible delivery, practical application, flexible examinations, student ownership, and continuous feedback mechanisms.

3.1. Use of e-learning

E-learning to facilitate distance learning and self-learning opportunities. This can be a solution in online learning in the Covid-19 pandemic, until one day learning becomes normal again, E-Learning can be used as a learning medium that can facilitate access to learning such as downloading teaching materials, Learning Implementation Design, materials, and to carry out evaluations (Firmansyah & Minandar, 2021).

Many E-learning platforms are accessible to educators such as Edmodo, Moodle, Google Classroom, and Whatsapp. Some of these platforms provide Learning Management System (LMS) facilities. In addition, it can be supported by a system that facilitates communication in the form of video conferences between educators and learners by using platforms such as Zoom, Google Meet, and Skype. E-learning also includes many methods that can effectively influence the learning process that presents learning content of various types to users, such as software collaboration and WBC (Web-Based-Courses) (Kacetl & Semradova, 2020).

In addition, there have recently been many uses of E-learning concepts such as Hybrid learning strategies (involving Flipped and Blended), Adaptive and Self-Directed Learning (Lalitha & Sreeja, 2020) used in learning. The benefits of hybrid learning can create a learning process to be effective, motivating, up to date, and oriented to effective communication skills (Dwijonagoro & Suparno, 2019).

So by using E-learning and integrating with learning strategies, it will apply a learner-centered approach to provide a lifelong learning process. In addition, learning natural sciences using E-learning can be categorized into three types of learning experiences, namely learning Natural Sciences with text-based, interactive and simulation learning.

As for some research that is considered the use of the concept of E-learning in elementary school natural science learning, judging from existing research:

1. The application of model 4 E-learning cycle has a positive and significant effect on the knowledge of Natural Sciences students at Kererobbo Elementary School with a sig value of 0.044 (Sole & Wilujeng, 2013).
2. E-learning has the advantage of improving the ability of science literacy and analytical thinking, to increase the motivation of learners (Setiaji & Dinata, 2020).
3. Learning Natural Science by using zoom application, Google Classroom, WhatsApp Group can make students more dependent in learning, by increasing self-awareness, self-regulation learning and good learning achievement.(Atmojo et al., 2020).
4. E-Portfolio development can improve science literacy. In addition E-Portfolio integrated with web blogs effectively improves students' science literacy to achieve multidimensional levels (Wijayanti & Basyar, 2016).

3.2. Personalised learning

Personalized learners can make learners learn with learning tools tailored based on their abilities. So that those who have difficulty in understanding the learning of Natural Sciences can provide

opportunities to practice more until they reach the required level. Some of the studies that can be an overview in applying personalized learning are:

1. Application of PAIKEM learning strategies by using animation media on Natural Science lessons that have a significant effect on the learning outcomes of elementary school students (Suparminingsih, 2016).
2. PjBL strategy with WBL media contributes to improving learning outcomes and understanding of integrated Natural Science learning concepts (Safaruddin et al., 2020).
3. Project-based learning model aided by network culture media can increase student activity (Yahya, 2014).
4. Science comic based on PBL as a learning medium on the theme of sound and hearing for students meets very feasible criteria and can improve learning outcomes, as well as students' critical thinking skills (F. Fatimah, 2014).

3.3. Flexible delivery

Flexible delivery, this is done by allowing students to modify their learning systems using tools, so students must have several different tools, programs and techniques based on their interests. In this change the application of blended learning, flipped classroom and BYOD (Bring Your Own Device) is very important to apply. Examples of digital learning forms such as AR, VR, DT.

Augmented Reality (AR) is a technology that is able to combine two-dimensional or three-dimensional virtual objects into a real environment or without changing the object of reality which is then presented or projected in real time (Handayani & Jumadi, 2021). As for some of the studies that are considered in applying AR, namely:

1. Augmented Reality (AR) learning media is worth using as a learning resource for students of grade V elementary (Mukti, 2019).
2. Learning systems using AR technology as teaching aids represented in virtual 3D form are packaged in the form of modules as creative and innovative media learning or props that can increase students' spirit in learning (Pujiastuti & Haryadi, 2020).
3. The use of Augmented Reality-based interactive multimedia can improve the abstract reasoning skills of elementary school fifth graders (Syawaludin et al., 2019).
4. The android version of AR learning media can help students understand the concept of human excretion systems and assist educators in achieving learning goals well (Qumillaila et al., 2015).
5. Augmented Reality-based learning media is very valid, so this learning media can be used in the learning process after making small revisions (Saputra et al., 2020).

Both Virtual Reality (VR) are simulations of 3D images or computer-generated environments that can interact in a real or physical way using special electronic equipment (Tvenge et al., 2020). VR technology is currently used in several disciplines for training and education, including engineering, computers, science, astronomy, and nursing, and is often touted as promising in many fields (Suparminingsih, 2016). As for some of the studies that are considered in the use of Virtual Reality (VR), namely:

1. VR applications turn abstract concepts into experience phenomena and present exciting opportunities to transform science education and practice (Kersting et al., 2021).
2. The use of Virtual Reality (VR) technology in teaching practice provides new possibilities for the development of problem-solving skills by providing students with richer situations, making the learning process more engaging and interactive, increasing motivation and attention, and helping them to discover and explore their own knowledge (Wu et al., 2021).
3. Exercise activities using VR have the potential to increase enjoyment and can increase motivation in doing exercises (Ulas & Semin, 2020).
4. VR helps creators consider top-down and bottom-up approaches in their learning design by describing the data collection process and the resulting benefits. In addition, you can create games that describe the subject matter authentically (Wang et al., 2019).

The third Digital Twin (DT) is a combination of Virtual Reality with Augmented Reality. DT has a prominent feature: its ability to correct itself unsupervised, by detecting systematic differences between measurement and prediction (Moya et al., 2020), but DT is still in development for learning activities (Tvenge et al., 2020). In addition to AR, VR, DT, learning strategies that can be used in Natural Science learning involving digital use, namely Flip-flop classroom is a learning strategy and blended learning approach where the delivery of content is mostly on-the-job-training (OJT), online or outside the classroom. Flip-flop classrooms can be arranged in several ways: (a) Bringing students field studies and explaining learning topics; (b) Before field study visits or class discussions, ask learners to watch TV shows related to home learning topics and discuss content in class/field trips (Lalitha & Sreeja, 2020).

3.4. Practical Application

Starting from a future that emphasizes a career that adapts to freelance economics, making natural science learning designed with project-based learning. This adaptation is considered necessary as well as applying skills to them in equipping them in the future. In addition, it is expected that natural science learning can integrate on organizational activities, collaboration, and time management in learning as a basis for learning. Some of the studies that can be taken into consideration are:

1. Effective application of PjBL teaching methodology to science learning in rural learning communities. Results show that didactic proposals had good results. In conclusion, science teaching tends towards more innovative educational methodologies such as PjBL (Project-Based Learning)(Santamaría-Cárdaba, 2020).
2. PjBL has an effect on the socio-cognitive variables most associated with STEM experiences and skills (Beier et al., 2019).
3. PjBL is more profitable for improving STEM learning compared to conventional. Furthermore, some of the effects observed for students attending school project-based learning, can make students become independent in choosing alternative learning environments (Craig & Marshall, 2019).
4. Project-based learning (PjBL) models in which autonomous group work is at the forefront of non-conventional learning delivery and assessment are used. Such use of Moodle has the potential to take advantage of the learning process when used as the primary communication platform (students and student-instructors) due to the many accessibility and versatility that such tools provide to instructors and students (Hussain & Jaeger, 2018).

3.5. Flexible Examinations

The traditional evaluation used is transformed into a special evaluation designed into an evaluation that measures the factual knowledge of students in natural science learning while the application is carried out direct project testing. Because as an evaluation consideration in the form of Q&A will lose its relevance in providing valid measurements of student abilities that are oriented to project-based learning (Koul & Nayar, 2021).

3.6. Student ownership

Ownership is discussed as a product or desired outcome for learners to achieve, this will help students engage more easily in the learning process. Therefore, this activity makes learners involved in forming the curriculum, in order to facilitate them in learning Natural Sciences independently (Koul & Nayar, 2021). Some of the studies that can be taken into consideration, namely:

1. Building and implementing student ownership and responsibility for their learning, can create school-wide practices that foster a culture of learning and engagement among students (Cannata et al., 2019).
2. Can describe the effectiveness of a learning that combines physical activity and digital modalities to empower students in exercising ownership for their learning (Chism & Wilkins, 2018).

3. One way to improve student achievement is through student ownership of learning and can enable students in learning. It then benefits students in promoting goal setting, self-assessment, and determination. As well as learning can be meaningful until they gain a better understanding (Chan et al., 2014).

3.7. *Continuous feedback mechanisms*

In the world of big data, advanced analytics that continues to grow, then learning assessment needs to switch from quantitative to qualitative, namely with criticism procedures carried out on an ongoing basis, this is better than natural science learning that provides a number assessment. Some of the studies that are used as examples are:

1. Teachers' formative assessments require guidelines and assignments in support of better child learning, and it is important to connect them to digital resources (Rahman Talukder et al., 2021)
2. The formative assessment practices described as having a significant effect on both motivational beliefs and behaviors involved in self-regulation during learning (Granberg et al., 2021).
3. The importance of student involvement in their learning activities and computer experience at both the individual and school level. So that technology-based assessment (TBA) makes measuring and evaluating student performance easier and more reliable (Chien & Wu, 2020).
4. Students design VR activities with a peer assessment learning approach have higher learning effectiveness (Chang et al., 2020).

4. CONCLUSION

The This research illustrates the digitization of effective elementary school natural science learning using E-learning, personalized learning, flexible delivery, practical application, flexible examinations, student ownership, and continuous feedback mechanisms. This research is limited to the digitization of learning in the context of elementary school natural science learning strategies, media and assessments. So that researchers provide recommendations for further research in order to describe the digitization of Natural Science learning, more broadly, covering the curriculum to digital pre-education, as a support for the implementation of elementary school natural science learning in the industrial era 4.0. This is intended to improve pedagogical abilities and knowledge practices in Indonesia.

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