REPUBLIK INDONESIA
KEMENTERIAN HUKUM DAN HAK ASASI MANUSIA

SERTIFIKAT PATEN SEDERHANA

Menteri Hukum dan Hak Asasi Manusia atas nama Negara Republik Indonesia berdasarkan Undang-Undang Nomor 13 Tahun 2016 tentang Paten, memberikan hak atas Paten Sederhana kepada:

Nama dan Alamat Pemegang Paten	: UNIVERSITAS AHMAD DAHLAN Jl. Pramuka 5F, Pandeyan, Umbulharjo, Yogyakarta, DI Yogyakarta 55161
Untuk Invensi dengan Judul	: METODE DAN SISTEM SIMULASI KEHIDUPAN BINATANG BERBASIS REALITAS VIRTUAL
Inventor	: Prof. Dr. Ir. Dwi Sulisworo, MT. Vera Yuli Erviana Bambang Robi'in
Tanggal Penerimaan	: 05 Oktober 2023
Nomor Paten	: IDS000007331
Tanggal Pemberian	: 02 Februari 2024

Pelindungan Paten Sederhana untuk invensi tersebut diberikan untuk selama 10 tahun terhitung sejak Tanggal Penerimaan (Pasal 23 Undang-Undang Nomor 13 Tahun 2016 tentang Paten).

Sertifikat Paten Sederhana ini dilampiri dengan deskripsi, klaim, abstrak dan gambar (jika ada) dari invensi yang tidak terpisahkan dari sertifikat ini.

a.n MENTERI HUKUM DAN HAK ASASI MANUSIA
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INFORMASI BIAYA TAHUNAN

Nomor Paten	: IDS000007331	Tanggal diberi	: 02 Februari 2024	Jumlah Klaim	: 3
Nomor Permohonan	: S00202309995	Tanggal Penerimaan	: 05 Oktober 2023		

Berdasarkan Peraturan Pemerintah Nomor 28 tahun 2019 tentang Jenis dan Tarif Atas Jenis Penerimaan negara Bukan Pajak Yang Berlaku Pada Kementerian Hukum dan Hak Asasi Manusia, biaya tahunan yang harus dibayarkan adalah sebagaimana dalam tabel di bawah.

Perhitungan biaya tahunan yang sudah dibayarkan adalah :

Biaya Tahunan Ke-	Periode Perlindungan	Batas Akhir Pembayaran	Tgl Pembayaran	Jumlah Pembayaran	Keterangan
1	05/10/2023-04/10/2024	01/08/2024	undefined	0	Klaim 3; Total Klaim: 0; Denda: 0
2	05/10/2024-04/10/2025	01/08/2024	undefined	0	Klaim 3; Total Klaim: 0; Denda: 0
3	05/10/2025-04/10/2026	06/09/2025	undefined	0	Klaim 3; Total Klaim: 0; Denda: 0
4	05/10/2026-04/10/2027	06/09/2026	undefined	0	Klaim 3; Total Klaim: 0; Denda: 0
5	05/10/2027-04/10/2028	06/09/2027	undefined	0	Klaim 3; Total Klaim: 0; Denda: 0

Perhitungan biaya tahunan yang belum dibayarkan adalah :

Biaya Tahunan Ke-	Periode Perlindungan	Batas Akhir Pembayaran	Biaya Dasar	Jml Klaim	Biaya Klaim	Total	Terlambat (Bulan)	Total Denda	Jumlah Pembayaran
6	05/10/2028-04/10/2029	06/09/2028	1.650.000	3	50.000	1.800.000	0	0	1.800.000
7	05/10/2029-04/10/2030	06/09/2029	2.200.000	3	50.000	2.350.000	0	0	2.350.000
8	05/10/2030-04/10/2031	06/09/2030	2.750.000	3	50.000	2.900.000	0	0	2.900.000
9	05/10/2031-04/10/2032	06/09/2031	3.300.000	3	50.000	3.450.000	0	0	3.450.000
10	05/10/2032-04/10/2033	06/09/2032	3.850.000	3	50.000	4.000.000	0	0	4.000.000

Biaya yang harus dibayarkan **hingga** tanggal 06-09-2028 (tahun ke-6) adalah sebesar Rp.1.800.000

- Pembayaran biaya tahunan untuk pertama kali wajib dilakukan paling lambat 6 (enam) bulan terhitung sejak tanggal diberi paten
- Pembayaran biaya tahunan untuk pertama kali meliputi biaya tahunan untuk tahun pertama sejak tanggal penerimaan sampai dengan tahun diberi Paten ditambah biaya tahunan satu tahun berikutnya.
- Pembayaran biaya tahunan selanjutnya dilakukan paling lambat 1 (satu) bulan sebelum tanggal yang sama dengan Tanggal Penerimaan pada periode pelindungan tahun berikutnya.
- Permohonan penundaan pembayaran biaya tahunan akan diterima apabila diajukan paling lama 7 hari kerja sebelum tanggal jatuh tempo pembayaran biaya tahunan berikutnya, dan bukan merupakan pembayaran biaya tahunan pertama kali.
- Dalam hal biaya tahunan belum dibayarkan sampai dengan jangka waktu yang ditentukan, Paten dinyatakan dihapus

(12) PATEN INDONESIA

(19) DIREKTORAT JENDERAL KEKAYAAN INTELEKTUAL

(11) IDS000007331 B

(45) 02 Februari 2024

(51) Klasifikasi IPC[8] : G 06F 40/197(2020.01), G 06F 3/01(2006.01), G 06T 19/00(2011.01)

(21) No. Permohonan Paten : S00202309995

(22) Tanggal Penerimaan: 05 Oktober 2023

(30) Data Prioritas :
(31) Nomor (32) Tanggal (33) Negara

(43) Tanggal Pengumuman: 16 Oktober 2023

(56) Dokumen Pembanding:
US20230290479-A1

(71) Nama dan Alamat yang Mengajukan Permohonan Paten :
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Pemeriksa Paten : Drs. Zulhelmi Yunus, M.Hum.

Jumlah Klaim : 3

(54) Judul Invensi : METODE DAN SISTEM SIMULASI KEHIDUPAN BINATANG BERBASIS REALITAS VIRTUAL

(57) Abstrak :

Invensi ini berhubungan dengan suatu metode dan sistem simulasi kehidupan binatang berbasis realitas virtual. Invensi ini menggambarkan metode dan sistem yang memungkinkan pengguna untuk melihat dan mengamati berbagai jenis hewan yang hidup di lingkungan virtual sesuai dengan habitatnya. Metode ini mencakup tampilan yang dipasang dimata berfungsi sebagai alat untuk melihat simulasi kehidupan binatang; pengontrol kiri berupa joystik berfungsi untuk menggerakkan kursor pandangan kamera maju dan mundur; Pengontrol kanan berupa joystik yang berfungsi untuk menggerakkan kursor pandangan camera ke kanan dan kiri; objek binatang terletak pada layar virtual yang menampilkan binatang tiga dimensi; papan petunjuk jalan terletak pada bagian layar virtual yang menunjukaan arah ke kanan dan ke kiri. Pada papan petunjuk tersebut terdapat tulisan binatang apa saja yang ada pada lokasi yang ditunjuk tersebut; tempat hidup binatang terdapat beberapa lokasi habitat binatang; jalan terdapat beberapa cabang jalan yang dilengkapi penunjuk jalan sebagai jalan utama untuk menuju lokasi binatang; papan informasi terdapat pada bagian pinggir jalan berfungsi sebagai tempat informasi jenis bintang yang ada pada area hewan tertentu. Sistem dari alat-alat dapat menampilkan lingkungan virtual habitat binatang yang dilengkapi dengan petunjuk jalan, menampilkan binatang dalam bentuk 3 dimensi, menampilkan teks deskripsi binatang, dan menampilkan suara yang menjelaskan tentang binatang tersebut.

Deskripsi

METODE DAN SISTEM SIMULASI KEHIDUPAN BINATANG BERBASIS REALITAS VIRTUAL

Bidang Teknik Invensi

Invensi ini mengenai metode dan sistem simulasi kehidupan binatang berbasis realitas virtual, lebih khusus lagi invensi ini berhubungan dengan kegiatan pembelajaran yang berhubungan dengan melihat dan mengamati bentuk, ciri khusus, dan perilaku binatang pada suatu lingkungan atau habitat virtual yang di buat menyerupai habitat pada lingkungan yang sebenarnya.

Latar Belakang Invensi

Invensi ini telah dikenal untuk menggunakan teknologi realitas virtual dalam pembelajaran dengan berbagai situasi belajar dan untuk berbagai tujuan atau kompetensi pembelajaran. Invensi ini bertujuan untuk memberikan pengalaman interaktif yang mendalam kepada pengguna, memungkinkan mereka untuk memahami lingkungan binatang secara holistik, mengamati perilaku binatang secara langsung, dan meningkatkan kemampuan berpikir kritis mereka melalui penerapan teknik hipotetika-deduktif.

Invensi teknologi dengan VR dengan tujuan terapi juga telah diungkapkan sebagaimana terdapat pada paten (US Patent) Nomor US-20230290479-A1 dengan judul Virtual Reality Therapy System and Methods of Making and Using Same dimana diungkapkan invensi tersebut berkaitan dengan penggunaan VR disertai headset dan beberapa sensor dapat menjadi terapi. Headset dipasang pada pasien yang akan diberi terapi tertentu. Selanjutnya lingkungan virtual dinyalakan untuk mengajak pasien melakukan aktivitas. Ketika pasien melakukan aktivitas, sensor tertentu akan merespon dengan memberikan data untuk tindakan lanjutan pada lingkungan virtual. Database yang ada pada sistem memberikan peluang pada terapi untuk pasien. Namun invensi tersebut masih terdapat kekurangan yaitu hanya berlaku pada lingkungaan virtual untuk aktivitas manusia.

Invensi lainnya sebagaimana diungkapkan pada paten (US Patent) Nomor US-20230215283-A1 dengan judul *Machine Learning-Based Educational Content Adaptation Based on User Personal Characteristics* dimana diungkapkan invensi tersebut berkaitan dengan metode untuk menyediakan materi pelajaran yang sesuai dengan karakteristik personal dengan menggunakan machine learning. Namun demikian invensi yang tersebut diatas masih mempunyai keterbatasan yang antara lain adalah invensi tersebut hanya menyediakan materi pelajaran dan belum sampai pada pencapaian kinerja pembelajaran.

Invensi lainnya sebagaimana diungkapkan pada paten (Indonesian Patent) Nomor IDS000006276 dengan judul *Sistem Pengalihan Rasa Takut Saat Pemeriksaan Gigi Berbasis Virtual Reality* dimana diungkapkan invensi tersebut berkaitan dengan aplikasi VR untuk membantu mengatasi rasa takut dan kecemasan pasien selama pemeriksaan gigi. Invensi ini mengintegrasikan beberapa komponen penting untuk menciptakan pengalaman yang lebih nyaman bagi pasien, seperti tempat untuk menempatkan ponsel pintar, tontonan VR yang akan digunakan selama perawatan gigi, audio yang menyediakan suara yang menenangkan atau musik yang membantu mengurangi ketegangan pasien. Namun invensi tersebut masih terdapat kekurangan yaitu invensi tersebut masih menggunakan ponsel cerdas yang tingkat keterlibatan pengguna masih kurang, tidak ada aktivitas lain bagi pengguna selain melihat dan mendengar.

Selanjutnya invensi yang diajukan ini dimaksudkan untuk mengatasi permasalahan yang dikemukakan diatas dengan cara menggunakan headset dan lingkungan virtual dengan multimedia.

Uraian Singkat Invensi

Tujuan utama dari invensi ini adalah untuk mengatasi permasalahan yang telah ada sebelumnya khususnya penggunaan VR dalam pembelajaran untuk peningkatan keterampilan berpikir kritis.

Perwujudan dari invensi ini adalah metode dan sistem simulasi kehidupan binatang berbasis realitas virtual terdiri dari: Headset

virtual reality berfungsi sebagai alat untuk melihat simulasi kehidupan binatang; pengontrol kiri berupa joystik berfungsi untuk menggerakkan kursor pandangan kamera maju dan mundur; Pengontrol kanan berupa joystik yang berfungsi untuk menggerakkan kursor pandangan camera ke kanan dan kiri; objek binatang terletak pada layar virtual yang menampilkan binatang tiga dimensi; papan petunjuk jalan terletak pada bagian layar virtual yang menunjukkan arah ke kanan dan ke kiri. Pada papan petunjuk tersebut terdapat tulisan binatang apa saja yang ada pada lokasi yang ditunjuk tersebut; tempat hidup binatang terdapat beberapa lokasi habitat binatang; jalan terdapat jalan yang bercabang yang dilengkapi dengan penunjuk jalan sebagai jalan utama untuk menuju lokasi binatang; papan informasi terdapat pada bagian pinggir jalan berfungsi sebagai tempat informasi jenis bintang yang ada pada area hewan tertentu; isi papan informasi terdapat pada papan informasi berfungsi untuk papan penjelasan yang lebih detail mengenai deskripsi hewan pada area tertentu; menu utama terletak pada bagian depan layar virtual berfungsi untuk memilih aplikasi habitat binatang; dicirikan dimana, objek binatang pada layar virtual berupa binatang tiga dimensi yang dilengkapi dengan informasi lengkap mengenai binatang tersebut, objek binatang juga dilengkapi dengan ciri-ciri fisik yang nyata sesuai dengan binatang aslinya seperti, warna binatang dan suara binatang.

Tujuan lain dari invensi ini adalah meningkatkan ketertarikan belajar dengan lebih dekat dengan hewan jinak maupun buas tanpa harus mendekati hewan asli secara langsung.

Tujuan dan manfaat-manfaat yang lain serta pengertian yang lebih lengkap dari invensi berikut ini sebagai perwujudan yang lebih disukai dan akan dijelaskan dengan mengacu pada gambar-gambar yang menyertainya.

Uraian Singkat Gambar

Gambar 1 adalah tampak perspektif simulasi kehidupan binatang berbasis realitas virtual.

Gambar 2 adalah diagram alir simulasi kehidupan binatang berbasis realitas virtual.

Uraian Lengkap Invensi

Invensi ini akan secara lengkap diuraikan dengan mengacu kepada gambar-gambar yang menyertainya. Mengacu pada Gambar 1, yang memperlihatkan metode simulasi kehidupan binatang berbasis virtual reality terdiri dari: Headset VR, pengontrol kiri, pengontrol kanan, dan aplikasi simulasi kehidupan binatang berbasis virtual reality.

Mengacu pada gambar 1 yang menunjukkan berbagai aktivitas dan fitur yang ada untuk observasi lingkungan virtual. Untuk dapat melakukan observasi lingkungan virtual, siswa sebagai pengguna mengenakan headset VR (1) dan mengambil pengontrol VR untuk tangan kiri (2) dan pengontrol VR untuk tangan kanan (3). Setelah headset VR (1) dinyalakan, pengguna akan memasuki lingkungan virtual yang berisi berbagai objek binatang (4), papan petunjuk jalan (5), lahan tempat hidup binatang (6), dan jalan (7) untuk menelusuri berbagai habitat binatang.

Pengguna dapat melakukan observasi lingkungan virtual yang menggambarkan kehidupan binatang di habitatnya. Selama di dalam lingkungan tersebut, pengguna dapat menelusuri berbagai objek binatang (4) baik di hutan tropis, gurun, pegunungan, dan kutub. Pergeralan maju dan mundur kamera pengguna dapat dilakukan menggunakan pengontrol di tangan kanan(3). Penelusuran dapat dilakukan dengan mengikuti papan petunjuk jalan (5) pada jalan (7) yang telah tersedia. Pengguna dapat berjalan ke depan, berputar dengan menggerakkan joystick yang ada pada pengontrol VR di tangan kiri (2). Selain itu pengguna juga dapat memutar badannya untuk melihat sekelilingnya. Objek binatang (4) dapat didekati dengan maju ke depan dengan cara menggerakkan joystick yang ada pada pengontrol VR di tangan kanan (3). Setelah didekati pada jarak tertentu, objek binatang (4) akan mengeluarkan suara binatang sesuai suara aslinya. Selama pengguna pada jarak tersebut, suara binatang tersebut akan terus terdengar. Suara ini keluar dari

headset VR (1). Selain itu, pada setiap tempat dimana objek binatang (4) berada, pada lahan tempat hidup binatang (6) tersedia papan nama binatang (8) dan tombol aktivasi (9). Papan nama binatang menuliskan nama dari objek binatang (4). Tombol aktivasi (9) berfungsi untuk memunculkan layar penjelasan ciri-ciri binatang (10). Untuk mengaktifkannya, pengguna dapat menekan pengontrol VR untuk tangan kanan (3). Ketika pengontrol VR untuk tangan kanan (3) ditekan maka sinar warna biru akan keluar dan harus diarahkan pada tombol aktivasi (9) dan muncul layar penjelasan ciri-ciri binatang (10).

Mengacu pada gambar 2, diagram alir simulasi kehidupan binatang berbasis virtual reality. Metode simulasi kehidupan binatang berbasis virtual reliaty terdiri dari: memasuki lingkungan virtual yang dilakukan dengan menggunakan headset VR; Menelusuri lingkungan virtual dengan bergerak ke kiri atau ke kanan sesaui petunjuk arah menggunakan pengontrol kiri dan menemukan lokasi suatu binatang; Mengamati binatang pada lokasi tersebut menggunakan layar; Melihat nama binatang melalui papan nama binatang yang ada pada lokasi melalui headset VR; menampilkan teks penjelasan mengenai binatang dan mendengarkan penjelasan deskripsi binatang.

Meskipun inti invensi telah digambarkan dalam bahasa yang khusus untuk fitur-fitur struktural dan/atau aksi-aksi metodologi, perlu dipahami bahwa pokok persoalan dalam klaim-klaim terlampir tidak perlu terbatas pada fitur-fitur atau aksi-aksi khusus yang digambarkan di atas. Namun, fitur-fitur dan aksi-aksi khusus yang digambarkan di atas di ungkapkan sebagai bentuk-bentuk contoh untuk mengimplementasikan klaim-klaimnya.

Uraian di atas tersebut dari invensi ini telah disediakan untuk tujuan ilustrasi. Perlu dipahami oleh orang yang ahli di bidang teknik ini di mana invensi ini bisa mudah diwujudkan dalam banyak bentuk yang berbeda tanpa keluar dari ide teknis atau fitur-fitur penting darinya. Jadi, perwujudan yang dinyatakan di sini perlu dipertimbangkan dalam pengertian deskripsi saja dan bukan untuk tujuan pembatasan.

Lingkup dari invensi ini didefinisikan pada klaim-klaim berikut. Jadi, perlu dipahami invensi ini mencakup semua modifikasi seperti itu yang disediakan berada dalam lingkup dari klaim-klaim terlampir.

Klaim

1. Metode simulasi kehidupan binatang berbasis realitas virtual terdiri dari:

Tampilan yang dipasang di mata (1) berfungsi sebagai alat untuk melihat simulasi kehidupan binatang;

Pengontrol kiri (2) berfungsi untuk menggerakkan kursor pada layar virtual bergerak maju dan mundur;

Pengontrol kanan (3) berfungsi untuk menggerakkan untuk kursor pada layar virtual ke kanan dan ke kiri;

objek binatang (4) terletak pada layar virtual yang menampilkan binatang tiga dimensi;

papan petunjuk jalan (5) terletak pada bagian layar virtual yang menunjuk dan mengarahkan pengguna untuk menuju ke lokasi suatu binatang;

lokasi tempat hidup binatang (6) terdapat beberapa lokasi habitat binatang yang disesuaikan dengan karakteristik habitat binatang pada lingkungan sebenarnya;

jalan (7) terdapat jalan yang bercabang yang dilengkapi penunjuk jalan (5) sebagai jalan utama untuk menuju lokasi binatang;

papan informasi (8) terdapat pada bagian pinggir jalan (7) berfungsi sebagai tempat informasi jenis bintang yang ada pada area tertentu;

isi papan informasi (9) terdapat pada papan informasi (8) berfungsi untuk papan penjelasan yang lebih detail mengenai deskripsi hewan pada area tertentu;

menu utama (10) terletak pada bagian depan layar virtual berfungsi untuk memilih aplikasi habitat binatang;

objek binatang (4) pada layar virtual berupa binatang tiga dimensi yang dilengkapi dengan informasi lengkap mengenai binatang tersebut, objek binatang juga dilengkapi dengan ciri-ciri fisik yang nyata sesuai dengan binatang aslinya seperti, warna binatang dan suara binatang.

2. Metode simulasi kehidupan binatang berbasis realitas virtual menurut klaim 1, dimana pengguna dapat menelusuri ruang

simulasi virtual, melihat dan mengamati binatang-binatang yang ada di lingkungan virtual.

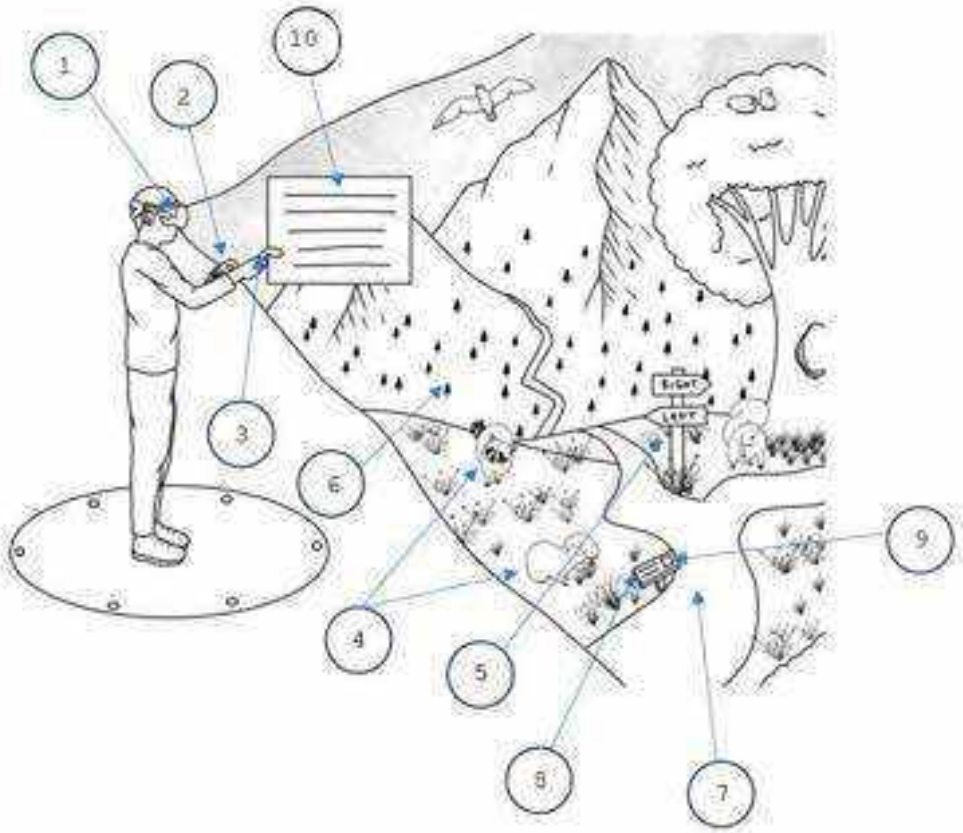
3. Metode simulasi kehidupan binatang berbasis realitas virtual, dimana sistem dari alat-alat dapat menampilkan lingkungan virtual habitat binatang yang dilengkapi dengan petunjuk jalan, menampilkan binatang dalam bentuk 3 dimensi, menampilkan teks deskripsi binatang, dan menampilkan suara yang menjelaskan tentang binatang tersebut.

Abstrak

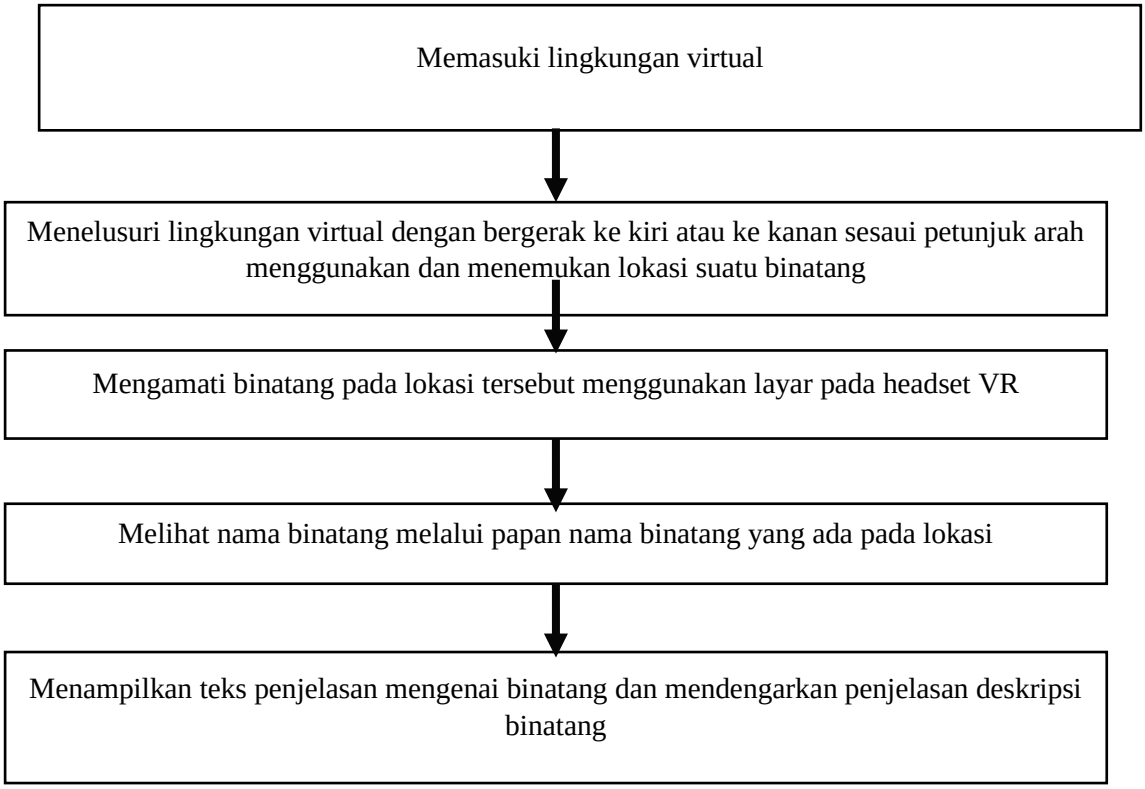
METODE DAN SISTEM SIMULASI KEHIDUPAN BINATANG BERBASIS REALITAS VIRTUAL

Invensi ini berhubungan dengan suatu metode dan sistem simulasi kehidupan binatang berbasis realitas virtual. Invensi ini menggambarkan metode dan sistem yang memungkinkan pengguna untuk melihat dan mengamati berbagai jenis hewan yang hidup di lingkungan virtual sesuai dengan habitatnya. Metode ini mencakup tampilan yang dipasang dimata berfungsi sebagai alat untuk melihat simulasi kehidupan binatang; pengontrol kiri berupa joystik berfungsi untuk menggerakkan kursor pandangan kamera maju dan mundur; Pengontrol kanan berupa joystik yang berfungsi untuk menggerakkan kursor pandangan camera ke kanan dan kiri; objek binatang terletak pada layar virtual yang menampilkan binatang tiga dimensi; papan petunjuk jalan terletak pada bagian layar virtual yang menunjukaan arah ke kanan dan ke kiri. Pada papan petunjuk tersebut terdapat tulisan binatang apa saja yang ada pada lokasi yang ditunjuk tersebut; tempat hidup binatang terdapat beberapa lokasi habitat binatang; jalan terdapat beberapa cabang jalan yang dilengkapi penunjuk jalan sebagai jalan utama untuk menuju lokasi binatang; papan informasi terdapat pada bagian pinggir jalan berfungsi sebagai tempat informasi jenis bintang yang ada pada area hewan tertentu. Sistem dari alat-alat dapat menampilkan lingkungan virtual habitat binatang yang dilengkapi dengan petunjuk jalan, menampilkan binatang dalam bentuk 3 dimensi, menampilkan teks deskripsi binatang, dan menampilkan suara yang menjelaskan tentang binatang tersebut.

GAMBAR 1



GAMBAR 2


Memasuki lingkungan virtual
Menelusuri lingkungan virtual dengan bergerak ke kiri atau ke kanan sesaui petunjuk arah menggunakan dan menemukan lokasi suatu binatang
Mengamati binatang pada lokasi tersebut menggunakan layar pada headset VR
Melihat nama binatang melalui papan nama binatang yang ada pada lokasi
Menampilkan teks penjelasan mengenai binatang dan mendengarkan penjelasan deskripsi binatang

Direktorat Riset dan Pengabdian Masyarakat Direktorat Jenderal Riset dan Pengembangan
Kementerian Riset, Teknologi, dan Pendidikan Tinggi
Gedung BPPT II Lantai 19, Jl. MH. Thamrin No. 8 Jakarta Pusat
https://simlitabmas.ristekdikti.go.id/

LAPORAN AKHIR PENELITIAN MULTI TAHUN

ID Proposal: 6cf9f29c-88da-4bce-88fb-545eac001990
laporan akhir Penelitian: tahun ke-2 dari 2 tahun

1. IDENTITAS PENELITIAN

A. JUDUL PENELITIAN

Penguatan Keterampilan Berpikir Kritis dengan Strategi Pembelajaran Berbasis Hipotetikal-Deduktif Berbantuan Virtual Reality Tema Ekosistem (Zoo-VR)

B. BIDANG, TEMA, TOPIK, DAN RUMPUN BIDANG ILMU

Bidang Fokus RIRN / Bidang Unggulan Perguruan Tinggi	Tema	Topik (jika ada)	Rumpun Bidang Ilmu
Sosial Humaniora, Seni Budaya, Pendidikan Penelitian Lapangan Dalam Negeri (Menengah)	-		

C. KATEGORI, SKEMA, SBK, TARGET TKT DAN LAMA PENELITIAN

Kategori (Kompetitif Nasional/ Desentralisasi/ Penugasan)	Skema Penelitian	Strata (Dasar/ Terapan/ Pengembangan)	SBK (Dasar, Terapan, Pengembangan)	Target Akhir TKT	Lama Penelitian (Tahun)
Penelitian Desentralisasi			SBK Riset Dasar	3	2

2. IDENTITAS PENGUSUL

Nama (Peran)	Perguruan Tinggi/ Institusi	Program Studi/ Bagian	Bidang Tugas	ID Sinta	H-Index
DWI SULISWORO - Ketua Pengusul	Universitas Ahmad Dahlan	Pendidikan Fisika	Konseptuakisasi penelitian, pengelolaan sumberdaya penelitian, supervisi dan monitoring ketercapaian,	23060	9

dengan bukti kemajuan ketercapaian luaran sesuai dengan luaran yang dijanjikan. Lengkapi isian jenis luaran yang dijanjikan serta mengunggah bukti dokumen ketercapaian luaran wajib dan luaran tambahan melalui BIMA.

Luaran wajib

Artikel pada Jurnal Internasional Bereputasi (Q2)

Judul : *Application of Cognitive Load Theory in VR Development and Its Impact on Learning: A Perspective on Prior Knowledge, Learning Interest, Engagement, and Content Comprehension*

Penulis : Dwi Sulisworo, Vera Yuli Erviana, Bambang Robiin

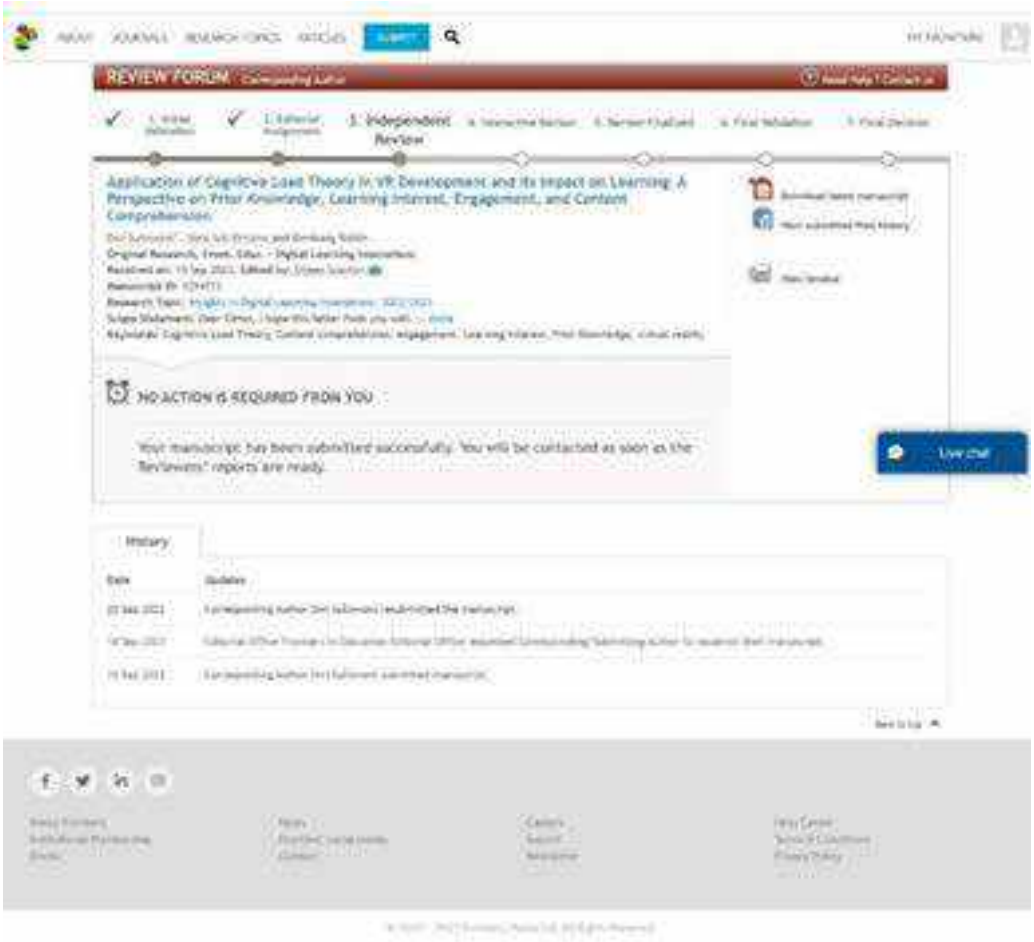
Nama Jurnal : Frontiers in Education

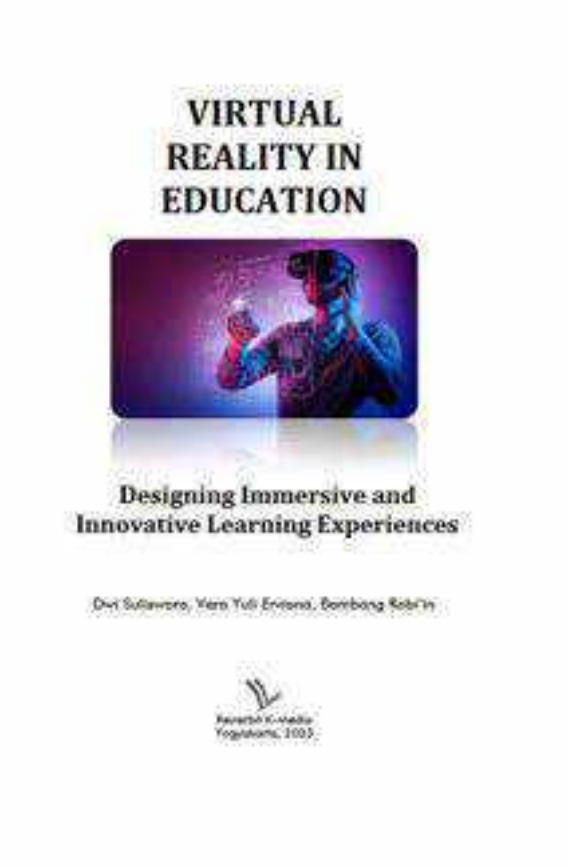
Alamat Web : https://www.frontiersin.org/journals/education

SJR : 0.661

Status Luaran : *Revision Required*

Bukti :





2. Publikasi di prosiding Seminar Internasional

Judul	: *Enhancing Elementary School Students' Environment Awareness Through Virtual Reality Based Immersive Learning Experiences*
Penulis	: Dwi Sulisworo, Vera Yuli Erviana, Bambang Robiin
Nama Konferensi	: *EDULEARN23 (15th annual International Conference on Education and New Learning Technologies)*
Tanggal	: 3-5 Juli 2023
Lokasi	: Palma, Spain
Alamat Web	: https://library.iated.org/publications/EDULEARN23
Alamat Artikel	: https://library.iated.org/view/SULISWORO2023ENH
Status Luaran	: Terlaksana
Bukti	: Sertifikat, Screenshot Artikel

ENHANCING ELEMENTARY SCHOOL STUDENTS' ENVIRONMENT AWARENESS THROUGH VIRTUAL REALITY BASED IMMERSIVE LEARNING EXPERIENCES

3. Hak Cipta Book Referensi

Judul	: Model Pembelajaran Berbasis *Problem Based Learning* Berbantuan *Virtual Reality* untuk Peningkatan HOTS Siswa
Penulis	: Dwi Sulisworo, Vera Yuli Erviana, Bambang Robiin
Status Luaran	: *Grantted*
Bukti	: Sertifikat HKI
Link sertifikat	: https://drive.google.com/file/d/1svAR9OCsdWKluCmw1d_hSwGiIXXLwryd/view?usp=sharing

SURAT PENCATATAN CIPTAAN

4. Hak Cipta Book Chapter
   Judul : *Virtual Reality In Education: Designing Immersive And Innovative Learning Experiences*
   Penulis : Dwi Sulisworo, Vera Yuli Erviana, Bambang Robiin, Eva Rismawati Nur Afina
   Status Luaran : *Grantted*
   Bukti : Sertifikat HKI
   Link sertifikat :
   https://drive.google.com/file/d/1IpUeippDXkkC4fbiS0Q34B05_DuOSrc7/view?usp=sharing

SURAT PENCATATAN

CIPTAAN

5. Paten Sederhana

Judul : Metode dan Sistem Simulasi Kehidupan Binatang Berbasis Realitas Virtual
Penulis : Dwi Sulisworo, Vera Yuli Erviana, Bambang Robiin
Status Luaran : *Diterima DJKI*
Bukti : Bukti Penerimaan Dokumen

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Data Permohonan (Application)

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Judul / Title	: METODE DAN SISTEM REALITAS VIRTUAL UNTUK MENGEMBANGKAN KETERAMPILAN BERPIKIR KRITIS MELALUI SIMULASI KEHIDUPAN BINATANG DI HABITATNYA		

Jakarta, 23 November 2023

Pemohon / Kuasa

Applicant / Representative

Tanda Tangan / *Signature*

Nama Lengkap / *Fullname*

6. Presentasi Hasil Penelitian

Berikut presentasi hasil penelitian skema PDUPT:
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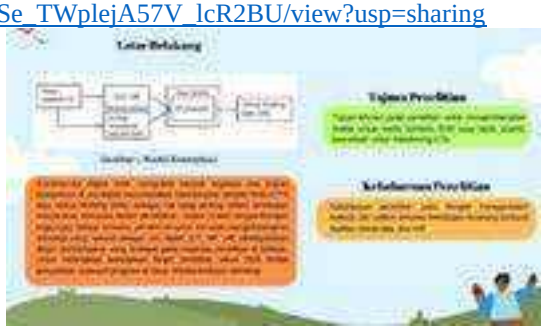

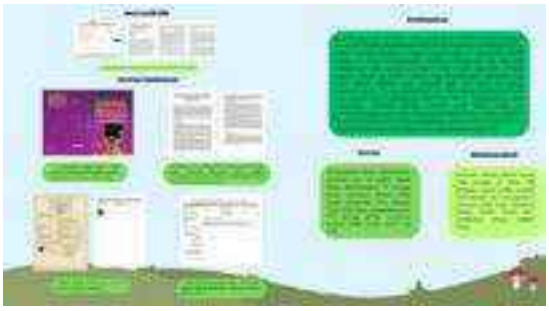

7. Video Kegiatan

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E**. PERAN MITRA:** Tuliskan realisasi kerjasama dan kontribusi Mitra baik *in-kind* maupun *in-cash* (untuk Penelitian Terapan, Penelitian Pengembangan, PTUPT, PPUPT serta KRUPT). Bukti pendukung realisasi kerjasama dan realisasi kontribusi mitra dilaporkan sesuai dengan kondisi yang sebenarnya. Bukti dokumen realisasi kerjasama dengan Mitra diunggah melalui BIMA.

Tidak ada mitra untuk PDUPT. Dalam penelitian ini telah dilibatkan beberapa sekolah untuk ijo coba dan respon pengguna VR. Selain itu juga dilibatkan dua destinasi wisata.

F. **KENDALA PELAKSANAAN PENELITIAN**: Tuliskan kesulitan atau hambatan yang dihadapi selama melakukan penelitian dan mencapai luaran yang dijanjikan, termasuk penjelasan jika pelaksanaan penelitian dan luaran penelitian tidak sesuai dengan yang direncanakan atau dijanjikan.

Kendala-kendala dalam pelaksanaan penelitian ini memberi berdampak terhadap kemajuan dan hasil penelitian. Untuk mengatasi kendala-kendala tersebut, berikut beberapa kendala dan solusi:

1. Keterlambatan Dana
   a. Komunikasi dengan LPPM UAD: Kegiatan-kegiatan yang dapat dilakukan tanpa pendanaan, dijalankan terlebih dahulu. Seperti penyusunan instrumen, penggunaan aplikasi yang tidak berbayar.
   b. Evaluasi Anggaran: Beberapa aktivitas disesuaikan mekanisme/ tahapan pendanaannya sehingga ada beberapa aktivitas yang dijalankan namun pendanaan dibayarkan setelah dana turun.

2. Tempat untuk *Sabbatical Leave*
   Koordinasi dengan perguruan tinggi mitra: karena kebijakan mitra awal terkait program ini yang tidak dapat dilakukan, maka dilakukan pemindahan *sabbatical leave* ke Universiti Teknologi Melaka, Malaysia.

G**. RENCANA TAHAPAN SELANJUTNYA:** Tuliskan dan uraikan rencana penelitian di tahun berikutnya berdasarkan indikator luaran yang telah dicapai, rencana realisasi luaran wajib yang dijanjikan dan tambahan (jika ada) di tahun berikutnya serta *roadmap* penelitian keseluruhan. Pada bagian ini diperbolehkan untuk melengkapi penjelasan dari setiap tahapan dalam metoda yang akan direncanakan termasuk jadwal berkaitan dengan strategi untuk mencapai luaran seperti yang telah dijanjikan dalam proposal. Jika diperlukan, penjelasan dapat juga dilengkapi dengan gambar, tabel, diagram, serta pustaka yang relevan. Jika laporan kemajuan merupakan laporan pelaksanaan tahun terakhir, pada bagian ini dapat dituliskan rencana penyelesaian target yang belum tercapai.

Rencana Tahapan Lanjutan

Hasil yang diperoleh relatif bagus. Beberapa tindaklanjut adalah:

1. Menyelesaikan kekurang luaran dengan beberapa penyesuaian
2. Mensosialisasikan produk pembelajaran dalam kegiatan pengabdian kepada masyarakat

H. DAFTAR PUSTAKA: Penyusunan Daftar Pustaka berdasarkan sistem nomor sesuai dengan urutan pengutipan. Hanya pustaka yang disitasi pada laporan kemajuan yang dicantumkan dalam Daftar Pustaka.

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X-Media

VIRTUAL REALITY IN EDUCATION

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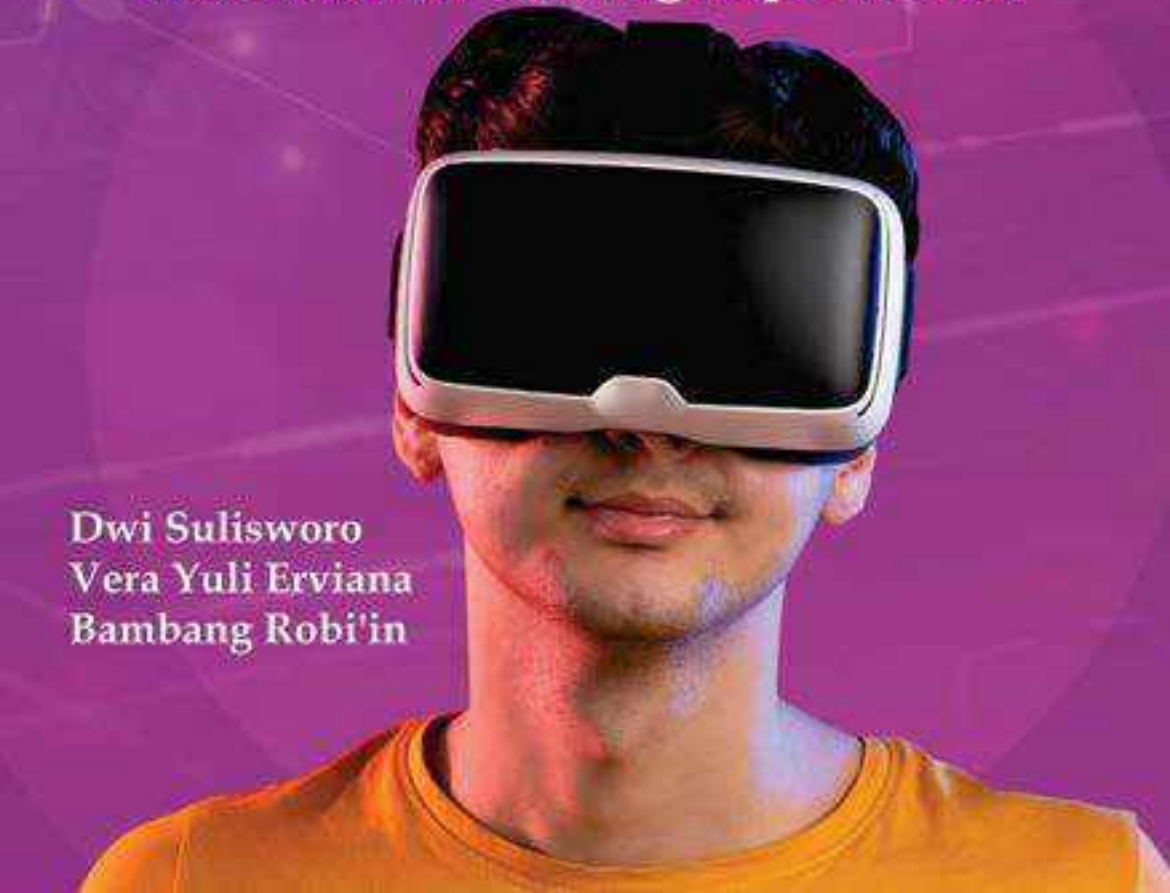

Dwi Sulisworo
Vera Yuli Erviana
Bambang Robi'in

VIRTUAL REALITY IN EDUCATION

Designing Immersive and Innovative Learning Experiences

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FOREWORD

We praise and thank God for the presence of Almighty God because of His abundance of Grace and Grace so that the book *"Virtual Reality In Education: Designing Immersive and Innovative Learning Experiences"* can be prepared smoothly and on time. This book has been prepared systematically so that elementary school teachers can understand technology-based learning models and to improve students' critical thinking skills. This book contains types of learning models, types of learning media, virtual reality, and student HOTS. Finally, our thanks and appreciation go to:

1. Ministry of Education and Culture, Research and Technology, which has funded the creation of a book on *Virtual Reality In Education: Designing Immersive and Innovative Learning Experiences*
2. All parties who helped in compiling this guidebook.

Future improvements and changes to this guidebook are always open and possible considering ongoing developments in the situation, policies and regulations. The compiler realizes that this book is still very far from perfection, both in terms of the form of preparation and the material. The authors really hope for suggestions from readers for further improvement of this book. Finally, I hope this book can provide benefits to elementary school teachers.

Yogyakarta, November 2023

Compiler

TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

1.1. Interactive learning and VR as innovative learning tools

Interactive learning is a learning approach that gives students active opportunities to be involved in the teaching and learning process. In interactive learning, students are not only recipients of information, but also actively participate in exploration, problem solving, and collaboration (Kim, 2006). This learning method can increase student engagement, motivate them to learn, and help strengthen understanding of the concepts being taught. Virtual Reality (VR) is a technology that allows users to feel and interact with an artificial environment that looks and sounds real through the use of a VR headset. VR has been widely applied in various fields, including education. The use of VR in learning offers an innovative and engaging approach to providing students with a more immersive and engaging learning experience (Johnston et al., 2018). Here are some reasons why interactive learning and the introduction of VR as an innovative learning tool are important.

1.2. Increase Student Engagement and Motivation

By enabling students to interact directly with learning content through immersive VR experiences, learning becomes more engaging and engaging (Lartigue et al., 2014). In a VR environment, students can actively engage with realistically replicated objects, environments, or situations. They can explore, observe, experiment, or interact in ways

that are not possible in conventional learning. Students' confidence in learning materials can be increased because they can see and feel concepts or phenomena directly (C. K. Lee & Shea, 2020). For example, in science lessons, students may conduct virtual experiments in a laboratory or explore different natural environments to study biodiversity. In history lessons, they can visit historical sites and experience important moments in historical events. Immersion in a VR environment can also trigger students' emotions, such as curiosity, awe, or excitement, which can increase their motivation to learn more deeply (Sanderink, 2018). They feel personally involved in the learning process, because they have control over their experiences and can explore according to their interests and wishes. In addition, the use of VR can also increase student involvement through its interactive aspects. Students can actively participate in simulations or activities in a virtual environment, make decisions, solve problems, or collaborate with fellow students (Wu et al., 2021). This encourages their critical thinking, creativity, and problem solving skills. Overall, the use of VR in learning creates a more engaging and engaging experience for students. They feel more involved in the learning process and feel the use of learning materials in real contexts. Students' motivation increases because they see the value and relevance of learning in their daily lives. Thus, the use of VR can increase the effectiveness of learning and encourage students to learn deeper and more actively.

1.3. Deeper Understanding of Concepts

Through the use of VR, students can experience abstract or difficult-to-understand concepts firsthand. The 3D environment generated by VR allows students to explore a virtual created world and visualize concepts that previously existed only in text or static images (Sanchez et al., 2000). In a VR environment, students can observe objects or phenomena on a more real scale. They can see objects or objects from different points of view, approach or move away from them, or zoom in and out of them (Wu et al., 2021). The ability to see and manipulate objects interactively provides a better understanding of the characteristics and relationships between these objects. In addition, interactive simulations in VR allow students to carry out experiments or explorations in a safe and controlled context. For example, in the field of physics, students can do simulation experiments where they can change certain variables and see the effect in real time. This helps them understand physics concepts in a practical and intuitive way. By experiencing concepts in a VR environment, students can gain a deeper understanding and reinforce the concepts being taught. They can see and feel the real application of the concept, making it easier for them to relate theory to practical experience. It also helps students overcome difficulties in understanding abstract concepts, because they can see them visually and interact with them directly. Overall, the use of VR in learning allows students to experience concepts firsthand, visualize them in 3D environments, and carry out interactive simulations. This helps them gain a deeper understanding, reinforce concepts, and relate them to practical experience. As such, VR becomes an invaluable tool in enhancing student learning in areas that are difficult to understand conventionally.

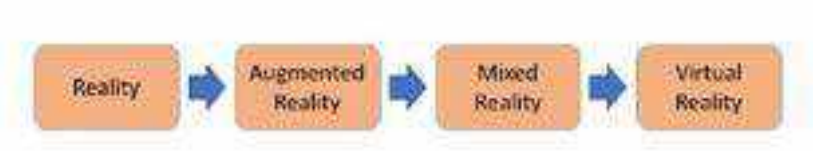

Figure 1. Extended Reality

1.4. Experience Based Learning

VR allows students to learn through hands-on experience, which can improve their information retention and understanding. In a VR environment, students can be actively involved and participate in simulations, experiments or real-world situations that are difficult to access in conventional learning. In a VR simulation, students can enter a virtually replicated environment, such as a laboratory, space chamber or animal habitat. They can see the object, environment, or phenomenon being studied in real terms, and even feel the sensation of being physically there. This allows students to gain immersive and immersive hands-on experience (Arini, 2023). In addition, students can participate in virtual experiments where they can change variables and see firsthand their impact on the outcome or event being studied. They can make observations and analyze the situation, and gain a stronger understanding of cause- and-effect relationships. In the context of learning history or culture, VR can take students to historical or cultural places that are far away or difficult to physically access. They can explore the pyramids of ancient Egypt, walk through historical cities or experience important historical events (Youngblut, 1998). This gives students an immersive visual experience and helps them understand the historical or cultural context better. Through interaction with the

environment that is represented virtually, students can see, feel and interact with objects, characters or the environment in ways that are not possible in conventional learning. They can gain deeper experience and more active involvement in the learning process. Overall, the use of VR in learning allows students to learn through immersive hands-on experience. They can participate in simulations, experiments or real-world situations that are difficult to access in conventional learning. Seeing, feeling, and interacting with a virtually represented environment helps students gain a better understanding and increases information retention.

1.5. Collaboration and Communication

VR also allows students to collaborate in the same virtual space. In a VR environment, students can interact with fellow students or teachers in real-time, even if they are in physically different locations. They can communicate, share knowledge, and work together to complete tasks or solve complex problems. The ability to collaborate in VR takes the learning experience to another level. Students can have discussions, share ideas, or provide feedback to one another through their virtual avatars (Suri et al., 2023). This opens up space for multiple perspectives and approaches to solving problems, as well as enhancing students' communication and teamwork skills. In addition, collaboration in virtual spaces prepares students for life and work in an increasingly connected world. In today's work environment, working virtually with colleagues from multiple geographic locations is becoming increasingly common. By collaborating in VR, students can develop important teamwork, communication, and project

management skills in a digitally connected environment. Collaboration in virtual spaces also allows students to benefit from expertise or knowledge shared by others around the world. They can connect with experts or specialists in a particular field, participate in collaborative discussions or projects, and expand their social network. This opens up new opportunities for

Cross-cultural learning, knowledge exchange, and joint problem solving. Overall, the ability to collaborate in virtual spaces brings significant advantages in learning. Students can interact, share knowledge, and cooperate with fellow students or teachers in a virtually represented environment. It strengthens students' communication and teamwork skills, and prepares them for life and work in a world that is increasingly connected and dependent on collaboration.

1.6. Enrichment of Learning Experiences

Experiences delivered through VR can provide opportunities that are not possible in traditional learning contexts. VR allows students to visit historic sites, explore natural environments, or dive into the underwater world in a way they have never done before. In history lessons, for example, students may experience travel through time and space, visiting historical places that may be difficult or expensive to physically access. They can walk through ancient ruins, interact with historical characters, or witness key moments within history (Cao & Feng, 2019). These experiences enrich students' understanding of the historical context and help them connect more deeply to the subject matter. In science, VR allows students to explore underwater worlds, see rare animals in their natural habitat, or study

complex ecosystems. Students can virtually interact with sea creatures, study their behavior, or even see the effects of climate change on coral reefs. This experience broadens students' horizons about biodiversity and the environmental challenges facing our planet. In addition, VR also allows students to dive into complex and abstract disciplines, such as physics or mathematics. In a VR environment, they can visualize complex concepts, interact with three-dimensional models, or run simulation experiments. This helps students develop a deeper and intuitive understanding of the concepts. The experiences presented through VR open up new insights for students. They can gain real experience that was previously not possible in conventional learning contexts. This enriches their learning, sparks interest and builds strong curiosity. As such, VR becomes an invaluable tool in providing opportunities that broaden students' understanding and take learning to a more immersive and enjoyable level. Interactive learning and the introduction of VR as an innovative learning tool bring many benefits and potential to change the way we learn and teach. By making good use of VR technology, education can be more interesting, relevant, and provide a better learning experience for students.

1.7. A brief history of the development of VR and its impact on education

The history of the development of Virtual Reality (VR) began in the 1960s, when several scientists and researchers began to develop the basic concepts and technologies that became the basis of modern VR. The following is an overview of the history of VR development and its impact on education:

1. The Beginning: In the 1960s, researchers such as Ivan Sutherland and Myron Krueger began developing the technology that became the basis of VR. Ivan Sutherland created "The Sword of Damocles", which is considered the first VR system. At the same time, Myron Krueger developed "Videoplace", an interactive space that allows users to interact with virtual objects.
2. Early Developments: In the 1980s and 1990s, VR saw further advancements. In 1989, Jaron Lanier coined the term "Virtual Reality" and founded the first VR company, VPL Research. More sophisticated VR systems were developed, including the development of VR headsets, motion sensors and other means of interaction. However, VR technology at that time was still limited and expensive, so it was not widely used in education.
3. Application in Education: In the 2000s, VR began to be applied in education. Educational institutions and software developers are leveraging VR technology to create more interactive and immersive learning experiences. VR applications in learning include scientific simulations, virtual tours, practical skills training, and customized learning environment experiences.
4. Decreasing Costs and Increasing Availability: In recent years, VR has become more affordable and accessible. The development of smartphone-based VR technologies, such as Google Cardboard and Samsung Gear VR, has made VR use more affordable and easier to implement in educational settings. Major companies such as Oculus Rift and HTC Vive have also released high-end VR headsets that provide a more immersive VR experience.

5. Benefits in Learning: The use of VR in education has had a significant positive impact. VR allows students to experience and explore environments and concepts that are difficult to access in person. For example, students can visit distant historical sites, explore the galaxy or conduct scientific experiments in a virtual environment. This experience increases students' understanding, engagement, and motivation in learning.
6. Future Developments: VR continues to experience development and innovation in the future. New technologies such as augmented reality (AR) and mixed reality (MR) have integrated elements of the real world with the virtual world, opening up new opportunities in learning. With further development, VR could become an important part of future education, changing the way we learn and teach.

The use of VR in education has had a significant impact on improving student learning experiences. As technology continues to evolve, VR can bring about greater changes in education, helping students learn interactively, broaden their horizons, and prepare them for the demands of an increasingly advanced world.

1.8. Theoretical Framework: VR for Enhanced Learning

The use of virtual reality (VR) in science classes has the potential to enhance student learning by bridging deep knowledge learning community with science instruction. When virtual environments reflect students' culture, it has the potential to influence their attitudes

towards the value of science in their communities (Bae, 2023). As virtual reality (VR) becomes more affordable, educational institutions are starting to integrate this technology into their curricula. Additionally, the increasing power of personal computers and supporting hardware has resulted in a revolution in graphic clarity, with increasingly complex simulations and realistic virtual worlds (Slater 2018). As Dickey (2005) notes, this has challenged and expanded the basic notion of what constitutes a learning environment. While previously limited to classroom instruction or field trips, VR's built-in capacity to give users a sense of presence and immersion has opened up new opportunities in education when done right (Hafner et al. 2018). The use of technology-assisted education approaches is not a new occurrence, and research into their effectiveness has been underway for about half a century. Ellinger and Frankland (1976) found that the early use of computers to teach economic principles provided learning outcomes comparable to traditional didactic approaches such as lectures in the 1970s. However, as Jensen and Konradsen (2018) point out, VR is new to HMD-based VR since the advent of the Oculus Rift in 2013. This has several consequences. Additionally, VR has enabled students to enhance cognitive skills through experiential learning, such as being exposed to settings that would be logistically difficult to visit in reality (Alişkan, 2011). For example, Bailenson et al. (2018) used HMD to immerse students in underwater settings to enhance learning about climate change. VR has made important contributions to education by enabling students to directly experience locations or scenarios that would be impossible to replicate using traditional teaching techniques such as lectures, image

presentations or 2D films. Due to the ever-changing nature of technology, it is difficult to provide a concise description of the fundamental properties of VR. However, Sherman and Craig (2003) stated "There are several important factors that must underlie a VR experience, which ultimately results in a virtual environment sensation similar to real life." This includes the need for immersive VR, Where participants' cognitive skills provide the sensation of being there and participating in a virtual world, often with limited awareness of what is going on around them in the real world. In addition, the virtual space must be interactive in the sense that the user can change the environment and test variables. Interacting with objects, virtual avatars, or even working with other real-life users in computer-generated areas is one example.

CHAPTER 2.
VR FUNDAMENTALS IN LEARNING

2.1. Basic definitions and concepts about VR

Virtual Reality (VR) is a technology that creates interactive and immersive experiences that mimic real or digitally created environments. In VR, users can experience and interact with the virtual world through the use of devices such as VR headsets, motion sensors and controllers. Some of the basic concepts related to VR are described below

2.1.1. Immersion

Immersion is an important concept in Virtual Reality (VR). This refers to an experience in which the user feels fully involved in the virtual environment created by VR technology. The main goal of VR is to create an immersive experience that provides real sensations and removes the user's awareness of the real world around them (Calvert & Abadia, 2020). Through the use of a VR headset that includes sight and hearing, users can feel as if they are in a virtual world. Stereoscopic vision and 360-degree view allow users to see and explore the environment in an immersive and realistic way. Meanwhile, spatial sound and 3D audio provide an immersive audio experience, allowing users to feel the immediacy and direction of sound in a virtual environment. In addition, VR can also use additional features such as vibrating devices or haptic devices to give the user physical sensations, such as touch or vibration, which enhances overall immersion. It aims to create a multisensory experience that

resembles the real world. By removing the user's awareness of their physical environment, VR immersion allows them to truly engage in the experiences provided by the virtual world. Users can explore the environment, interact with objects or characters, and experience events within the virtual environment. Immersive experiences in VR have the potential to enhance learning and understanding. In the context of education, students can experience it directly abstract or hard- to-understand subject matter through deep immersive experiences. They can learn concepts in a more practical and intuitive way, and develop a stronger understanding of the topic being studied. Overall, immersion is a key element in VR which aims to create fully immersive and realistic experiences within virtual environments. By leveraging VR technology, users can experience sensations and experiences similar to the real world, which open up new opportunities in education, entertainment and other fields.

2.1.2. Interaction

Interaction is one of the important aspects of Virtual Reality (VR). It refers to the user's ability to interact with objects, environments or characters in a virtual world created by VR technology. The goal of interaction in VR is to provide a responsive experience and allow users to feel the impact of their actions in a virtual environment (Bonner & Reinders, 2018). In VR, users can interact by using motion sensors and controllers connected to the VR system. Motion sensors, such as hand or body controllers, can detect

the user's physical movements and transfer them to the virtual environment. This allows users to move their hands, body or even legs in a virtual environment with appropriate gestures. The connected controller or joystick also allows the user to interact with objects or the environment in the virtual world. They can use the controller to select, manipulate or move objects, as well as perform other actions such as pressing buttons or moving levers. With this interaction capability, users can explore virtual environments, interact with objects such as picking up or placing things, solving puzzles, or even communicating with virtual characters. They can perform actions similar to those in real life, which provides a more immersive and involved experience. Interaction in VR has the potential to enhance student learning and experience. For example, in science lessons, students can perform interactive experiments or simulations in virtual environments, where they can change variables, observe results, or run different scenarios. This allows them to learn through exploration and experimentation, as well as understand concepts in a practical way. In addition, interaction in VR also allows collaboration between users. In a virtual space, users can interact with each other, work together on tasks or projects, or even communicate in the form of avatars or virtual characters. This opens up opportunities for team-based learning, discussion and joint problem solving. Overall, interaction is an important element in VR that allows users to interact with virtual objects and environments using motion sensors and controllers. This ability provides experiences that are more responsive and allow users to

feel the impact of their actions in virtual environments. Interaction in VR takes learning and exploration experiences to a higher level, allowing users to be actively and deeply engaged in the virtual environment they create.

2.1.3. Environment Customization

Environment customization is the ability in Virtual Reality (VR) to create and modify virtual environments according to user needs and goals. In VR, users can experience customizable environments, which range from simulated real environments to completely fictional or imaginative environments. In VR, virtual environments can be replicated with high precision to create simulations of real environments (Cardona-Reyes et al., 2020). For example, a virtual environment can mimic a classroom, scientific laboratory, historic site, or natural environment with a near-real level of detail. This allows users to interact with the environment as they would in the real world, gain immersive experiences and engage in learning. In addition, virtual environments can also be completely fictitious or imaginative environments. In this case, the user can experience a specially created world with elements that do not exist in the real world (Chang et al., 2023)impact. For example, virtual environments can create fantasy worlds, futuristic scientific worlds, or abstract environments that allow creative exploration and differential learning. Environment customization in VR gives users the flexibility to customize their experience. Users can choose the environment that is most relevant to their learning materials or goals. They

can also modify the environment according to their preferences, such as changing the lighting, texture, scale, or replacing existing objects. The use of environmental customization in VR has great potential in learning. For example, in an educational context, teachers can create learning environments that suit students' needs and learning objectives (Cardona-Reyes et al., 2021). They can choose or create environments that support effective learning experiences and gain deeper understanding. In addition, environmental customization also allows adaptation for students with special needs. For example, students with visual impairments can adjust the virtual environment to suit their needs, such as magnifying text or adjusting contrast. This ensures that the VR experience is accessible and useful for all students. Overall, environment customization is the ability in VR to create and modify virtual environments according to the user's needs and goals. It provides flexibility and creativity in VR experiences, allows users to experience real or imaginative environments, and supports effective and engaged learning.

2.1.4. Stereoscopy

Stereoscopy is a viewing method used in Virtual Reality (VR) to create a more realistic perception of depth and space. In stereoscopy, VR uses the principle that the human eye perceives slightly different images and combines them to produce three-dimensional perception. In VR, each user's eye sees a slightly different image. Typically, these two images are presented separately to each eye using a VR headset. By

combining these two images, the human brain can recognize differences in viewing angles and produce the illusion of depth (Chen et al., 2007). This principle takes advantage of the difference in perspective that occurs when the human eye is in a slightly different position. When looking at an object in the real world, our eyes see it from a slightly different perspective, and our brain uses this information to interpret the depth and distance of the object. In VR, stereoscopy technology generates two slightly different images and displays them to each eye. This creates an effect similar to a real- world experience, where the user is able to see objects with greater depth and dimension. The stereoscopic effect in VR provides a more immersive and involved visual experience. Users can experience the sensation that virtual objects or environments actually have real depth and distance. This provides a level of clarity and realism that enhances the overall VR experience (Cardona-Reyes et al., 2022). Stereoscopy also aids in navigation and interaction with virtual environments. With accurate depth perception, users can see distances between objects and navigate through the environment more easily. They can also interact with objects and manipulate them more precisely because of the depth perception provided by stereoscopy technology. Overall, stereoscopy is a visual method used in VR to create the perception of depth and space. By using two slightly different images presented to each user's eye, VR creates the illusion of depth and provides a more immersive and involved three-dimensional visual experience. Stereoscopic technology enhances realism and clarity in VR

Figure 2. VR Headset

2. Motion sensor. Motion sensors are used in VR to track the user's body movements, particularly head movements. These sensors allow users to see and interact with virtual environments in a more natural way. By tracking head movement, the motion sensor updates the visual display according to changes in the user's viewing angle, creating the illusion that the user is in a moving virtual environment. Motion sensors can use various technologies, such as inertial motion tracking technology, magnetic motion tracking technology, or camera-based tracking technology. These motion sensors are usually attached to VR headsets or placed around the room for whole body monitoring.
3. Controller. The controller in VR is the input device used by the user to interact with the virtual environment. This controller can be a hand controller, motion controller, or other input device. They allow users to manipulate objects, explore the environment, and perform other actions required in a VR context. Controllers usually come with various buttons, action buttons, joysticks, touchpads or additional motion

3.1.5. Language and Culture

Language and culture are closely related. In the context of Virtual Reality (VR), VR can be an effective tool in supporting language and cultural learning by providing immersive experiences for students. In language learning, VR can immerse students into the target language environment. Students can interact with virtual characters who speak the foreign language being studied (Johnson et al., 2001). They can practice speaking, listening and communicating in realistic contexts. It provides hands-on and interactive experience in strengthening language understanding and increasing confidence in communicating. Apart from that, VR also allows students to explore different cultural places. They can visit cities or locations that have a different culture, and experience the atmosphere and daily life in that culture. Through virtual environments, students can gain insight into the customs, traditions and values of different cultures visually and emotionally. This helps them broaden their understanding of the world and increase tolerance for cultural differences. In addition, VR can also provide simulations of everyday life situations in different cultures (Johnson et al., 2002). For example, students can participate in shopping simulations at traditional markets, eat at local restaurants, or attend cultural festivals. In a virtual environment, students can interact with virtual characters representing that culture and practice skills in a real context. This assists them in gaining a practical understanding of the culture, as well as enhancing cross-cultural communication skills. The

application of VR in learning language and culture provides significant benefits. By providing an immersive experience, VR allows students to interact directly with the target language and experience life in a different culture. This helps in strengthening language understanding, improving communication skills, and developing a deep understanding of culture. Overall, VR supports language and cultural learning by providing immersive experiences for students. Through VR, students can interact with virtual characters in the target language, explore places of different cultures, and participate in simulated situations of everyday life in different cultures (Johnston et al., 2018). The application of VR in language and cultural learning enables students to develop language skills, broaden cultural understanding, and enhance cross-cultural communication.

Figure 10. Mondly: Practice Language in VR

3.1.6. Practical Skills

Practical skills are skills that involve physical abilities and direct experience in performing certain tasks or activities. In the context of Virtual Reality (VR), VR can be used to train practical skills by providing safe and realistic simulations. In the medical field, VR can be used to train medical skills. Students can practice medical procedures such as catheter insertion, patient transfer, or surgical procedures in virtual simulations (Bonner & Reinders, 2018). In a virtual environment, they can interact with highly detailed models of the human body and practice techniques and procedures with real-time feedback. This provides an opportunity for students to hone their medical skills in a safe and controlled environment. In engineering and architecture, VR can help students build interactive architectural models. They can design buildings and environments in virtual environments, realistically visualize 3D designs, and interact with the models. In this process, students can hone planning, design, and problem-solving skills in a more visual and interactive context. Apart from that, VR can also be used to train manufacturing and crafting skills. For example, students can use VR to practice welding techniques, wood-cutting, or making other crafts in real time virtual environment (C.

K. Lee & Shea, 2020). They can practice the hand movements, hand-eye coordination and techniques necessary for manufacturing skills in a realistic and controlled manner. The application of VR in training practical skills provides significant benefits. By

providing safe, realistic and controllable simulations, VR enables students to practice practical skills in an environment similar to the real world. This helps them to develop physical skills, manual skills and technical abilities in areas that require hands-on experience. Overall, VR is used to train practical skills in areas such as medical skills, engineering, and craft skills. In VR, students can practice medical procedures in a safe virtual simulation, build interactive architectural models, or practice manufacturing skills in a virtual environment. The application of VR in training practical skills allows students to hone their skills in a controlled, realistic and effective environment. Apart from these fields, VR can also be applied in fields such as geography, psychology, physical education, and many more. By integrating VR into learning, students can have more immersive, interactive and engaging experiences that enhance their understanding, engagement and motivation in learning.

Figure 11. Hand Physics Lab VR Application

3.2. Virtual Reality: A Tool for Immersive Science Experiences

The implementation of Virtual Reality in education is beneficial because of its interactive and immersive nature. (Checa, 2020) Immersive technology offers a safe and controlled learning environment. In fields such as medicine or hazardous industrial settings, students can practice skills and procedures in a virtual environment without risk to themselves or others. This allows repeated practice and mastery of skills before they are applied in real-life situations. Simulations and virtual scenarios created through VR, AR and MR can provide opportunities for collaborative learning. Students can engage in virtual group activities, simulations, or problem solving assignments, which promote teamwork and communication skills. Technologies for virtual reality allow users to enter computer-generated environments and interact with them as if they were physically present. VR can provide invaluable and interactive experiences that can enhance student learning and scientific exploration. Here are some ways VR can be used for intense scientific research:

3.3. Virtual Lab Simulations

Virtual Lab Simulations are the use of Virtual Reality (VR) technology to create a laboratory environment that can be accessed and used virtually. In this VR environment, students and researchers can conduct experiments, practice laboratory techniques, and run a simulation similar to the actual experience in a physical laboratory (Blanchard et al., 1990). One of the main advantages of virtual lab simulations is safety and cost efficiency. In a virtual environment, students can learn and explore without the need for

expensive physical equipment or materials. They can conduct experiments and practice lab techniques in a safe environment, free from risk of injury or equipment damage. In addition, the use of virtual lab simulations also reduces costs associated with procuring and maintaining laboratory equipment. Virtual lab simulations also provide greater flexibility and accessibility. Students can access this virtual environment from anywhere and anytime via compatible VR devices. They are not limited by schedules or physical limitations of real laboratories. This allows students to learn and practice laboratory skills independently or in groups without being constrained by time or space constraints. In addition, the use of virtual lab simulations allows students to gain prerequisite knowledge and build cognitive abilities prior to working in a physical laboratory. Using a virtual environment, students can learn theory, master experimental steps, and develop an understanding of important concepts before moving on to practice in a physical laboratory(H. S. Lee & Lee, 2021). This allows students to focus fully on relevant activities in a real laboratory without being overwhelmed by basic understanding or practical instruction. The application of virtual lab simulations in education is a significant development. Studies and research have shown encouraging results in replacing or complementing physical laboratory work with virtual lab simulations(J. B. Lee & Kwon, 2022). VR can be a useful tool for acquiring prerequisite knowledge and developing cognitive abilities before undertaking practical work in the physical laboratory. This allows students to optimize their experience in a real laboratory and enhance their understanding and practical skills. Overall, virtual lab simulations enable students and researchers to conduct experiments and practice lab

techniques in a safe and cost- efficient virtual environment. This expands the potential use of virtual laboratories in education, helps students acquire prerequisite knowledge and cognitive abilities before working in real laboratories, and enhances the effectiveness of learning and exploration in science and research.

Figure 12. Car Mechanic Simulation

3.4. Field Trips and Expeditions

Field trips and expeditions are experiences where students can travel to places that are remote or physically inaccessible. In the context of Virtual Reality (VR), the use of VR allows students to take virtual journeys to places such as beautiful coral reefs, the vast outer space, or historical monuments located in distant locations. With the use of VR, students can explore and learn about the natural world and scientific phenomena in an up-close and personal way. For example, they can observe marine life on coral reefs in incredible detail, see stunning views of the universe or visit historical monuments with architectural beauty and rich cultural heritage. These experiences provide a unique

opportunity for students to see, hear, and feel these places, even if they cannot physically visit them. These virtual field trips and expeditions have great potential in arousing student curiosity and discovery. With the immersive experiences offered by VR, students can develop a deeper understanding of the topics studied, as well as gain real-world experience in studying natural and historical phenomena. They can observe and interact with the virtual environment in a way that is not possible in conventional learning. This can spark their imagination, strengthen their emotional connection with the subject matter, and increase their motivation to learn more. In addition, field trips and virtual expeditions can also provide students with broader and inclusive access. For example, students who are unable to take a physical trip due to physical limitations or other constraints can

experience the same virtual journey as everyone else. This ensures that every student has an equal opportunity to explore and learn about the wide world. The use of VR in field trips and expeditions provides significant benefits in learning. Through VR, students can explore remote or physically inaccessible places, study natural phenomena and history in depth, and develop a strong sense of curiosity and discovery. It opens doors for more inclusive learning and provides immersive experiences in understanding the world around us. Overall, field trips and virtual expeditions through the use of VR allow students to travel to places that are remote or physically inaccessible. In this experience, they can study the natural world, scientific phenomena, and historical heritage in a deep and personal way. The use of VR on field trips and expeditions fosters student curiosity and discovery, ensures greater accessibility, and enhances learning in understanding the wider world around us.

Figure 13. OtherSight VR Application

3.5. Data Visualization

Data visualization is the process of presenting data in a visual form that can be understood more easily. In the context of Virtual Reality (VR) .The use of VR in data visualization allows scientists and researchers to view and evaluate scientific data in a more immersive and interactive way in a three-dimensional environment. In VR, complex scientific data can be presented in a more dynamic and attractive visual form. Scientists can transform data into three-dimensional models, interactive graphs, or other visualizations that allow them to more clearly visualize relationships, patterns, and trends in data. By entering a VR environment, users can interact with the data using motion sensors or controllers, move, zoom, or rotate objects and graphics in 3D space. The use of VR in data visualization provides several advantages. First, the three-dimensional environment allows scientists to view data from multiple perspectives and gain a more comprehensive understanding of data structure and relationships. They can explore data in a more natural and intuitive way, allowing them to

discover new patterns and insights that might not be visible in two-dimensional visualization. Second, interactivity in a VR environment allows scientists to interact directly with data. They can change parameters, filter data, or get a closer look at details with hand or controller gestures. This provides an opportunity for scientists to carry out in-depth exploration and experimentation in understanding scientific data. The use of VR in data visualization also facilitates collaboration between scientists. Within the same VR environment, multiple users can view, interact, and discuss data together. This enables a richer exchange of ideas and perspectives, and promotes teamwork and shared learning in the understanding of scientific data. Overall, the use of VR in data visualization enables scientists and researchers to visualize and explore complex scientific data in an interactive three-dimensional environment. With the ability to transform, interact, and manipulate data in natural and engaging ways, scientists can gain deeper new understandings and knowledge about scientific data. This provides the potential to identify new patterns, relationships and insights that contribute to the advancement of scientific research and understanding.

Figure 14. Noda VR Application

3.6. A concrete example of implementing VR

The integration of VR technologies in primary education opens up new possibilities for immersive and interactive learning experiences. Virtual Reality (VR) can be used as a learning medium that can increase student involvement in learning (Utami et al., 2021). VR technology creates immersive, interactive, and multisensory virtual environments that simulate real-world experiences. By integrating VR into the learning environment, educators can provide primary school students with unique opportunities to explore, experiment, and engage in their educational journey (Cao & Feng, 2019). VR technology offers a unique platform to foster creativity and critical thinking skills in elementary school students. The immersive and interactive nature of VR encourages students to think critically, solve problems and make decisions in a virtual environment. Through virtual scenarios and simulations, students can explore different perspectives, analyze complex situations, and develop creative solutions. VR also provides opportunities for collaborative learning, allowing students to work together on solving challenges and developing communication and teamwork skills. The main benefit of computer-assisted instruction (CAI), also known as computer-based training (CBT), is the use of virtual reality (VR) in education. Several studies conducted since the 1990s have concluded that the use of VR enhances learning (McLellan 1996, 2003). Youngblut (1998) conducted a review of the use of VR in education since the early 1990s and found that VR has several unique capabilities, including components for constructivism-based instruction, accessible use by blind students, and a function as a learning facilitator. According

to some teachers, the use of VR is more accessible, more affordable, and easier for students and teachers to use. Virtual reality, also known as virtual reality, is a technology simulated by a smartphone or computer that allows users to interact with real or simulated environments by computer. In other words, the computer projects a virtual environment on VR media, so users feel as if they are entering the virtual world or environment (Abdillah et al., 2018). In general, virtual reality can be accessed via smartphones through special applications or YouTube videos. Students can improve their cognitive abilities by using VR in science learning. VR can be used in various educational contexts for various reasons. VR has the potential to inspire and motivate students in learning and encourage them to become creative learners. Winn (1993) mentions several benefits of VR in education, including:

1. VR provides non-symbolic human resources specifically created to assist students in learning course material.
2. The use of VR creates interactions with a third-person perspective that are similar to real life, although not always in everyday conversation.
3. Constructivism is the best philosophical framework for creating VR educational apps.
4. Allows students to resize any object in the Islamic world using a material not visible in the physical world (for example, warping hard objects).

According to Panthelis (1995), there are several reasons for using virtual reality in education:

1. VR offers new visualization formats and techniques by harnessing the power of visual representation. It provides a new way of conveying information. Because

VR can sometimes show characteristics, processes, and so on more accurately than anywhere else, close-up observations, remote observations, and observing and examining areas and events that are not available by other methods.

2. VR provides motivation to students. Education requires active interaction and involvement, not a passive attitude. Some VR applications, such as collaborative VR, incorporate text into a virtual world and require students to participate in a social environment.
3. VR allows students to study at their own pace and over longer periods of time without being tied to a schedule.

The teacher or instructor must be able to distinguish between material that can be integrated with virtual media and material that cannot be integrated. Usually, subjects have various learning classes in schools. If the use of virtual reality is used as an alternative to conventional media, teachers can use it in some of these learning classes with appropriate terms and conditions.

3.7. The benefits and advantages of using VR in achieving external learning

VR is usually understood as a technology that produces virtual immersion in a digital environment, thanks to which computer graphic simulation allows users to immerse themselves in an interactive three-dimensional world where various types of sensory and emotional experiences are encountered. Currently, with advances in technology, VR technology has

spread to various fields and sectors (Aznar, et al., 2017). For example, VR has been implemented in surgical education (e.g. Harrington et al., 2018; Yoganathan, Finch, Parkin, & Pollard, 2018), sports training (e.g. Panchuk, Klusemann, & Hadlow, 2018), language learning (e.g. Parmaxi, 2020). In education, the main reason why VR has become so popular is its immersive, imaginative and interactive features (Gavish et al., 2015). Blascovich et al. (2002) highlighted that its application allows students to be placed in a different environment with a realism that cannot be achieved with textbooks, while avoiding certain elements that can hinder learning. Its use in education allows students to become immersed in countless settings and time periods (Pe´rez- Martí´nez, 2011). Cuesta and Manas (2016) describe this technology as a tool capable of breaking through the space-time barriers of educational contexts, thereby achieving experiential learning. Two concepts can be considered key about VR: immersion and presence. They are often used interchangeably, but formally immersion describes the experience of using what is called an immersive technology, (Jensen & Konradsen, 2018), whereas presence refers to a subjective user's response to a VR situation in a way similar to that. that would occur in similar situations in the real world (Slater, 2003).

CHAPTER 4.
CHALLENGES AND FUTURE USE OF VR IN LEARNING

4.1. Challenges and constraints in using VR

The development and use of VR applications need to study the various dimensions of this technology. The VR challenge is one of the most important dimensions to define. Despite the benefits of using technology (such as VR) in healthcare, there are limitations. Individual variables, such as gender, age, personality and history of motion sickness, as well as other psychological, cognitive, physical and functional characteristics present in many clinical situations, are of great importance and must be taken into account (Annetta et al., 2009). The sensitivity of some patients must be taken into account, including their discomfort with using a head-mounted display (HMD), their ability to learn how to behave in a virtual environment, and the duration and potential adverse effects of the reality test itself. Due to ethical considerations, as well as the efficiency of VR-based teaching and care, these challenges must be addressed. According to Bricken, 1991, "Despite its obvious benefits, connecting VR to the learning process poses a unique set of difficulties. This is mostly related to the price and the technical competency of the teacher to use VR technology successfully. Commercial VR systems that are sophisticated enough to provide complex models and multiple features come at a hefty price." Commercial VR systems that are sophisticated enough to provide complex models and multiple features come at a hefty price (Bricken, 1991). To

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Pembelajaran interaktif merupakan pendekatan pembelajaran yang memberikan siswa kesempatan aktif untuk terlibat dalam proses belajar-mengajar. Dalam pembelajaran interaktif, siswa tidak hanya menjadi penerima informasi, tetapi juga berpartisipasi aktif dalam eksplorasi, pemecahan masalah, dan kolaborasi. Metode pembelajaran ini dapat meningkatkan keterlibatan siswa, memotivasi mereka untuk belajar, dan membantu memperkuat pemahaman konsep yang diajarkan.

Virtual Reality (VR) adalah teknologi yang memungkinkan pengguna untuk merasakan dan berinteraksi dengan lingkungan buatan yang tampak dan terdengar nyata melalui penggunaan headset VR. VR telah diterapkan secara luas dalam berbagai bidang, termasuk pendidikan. Penggunaan VR dalam pembelajaran menawarkan pendekatan yang inovatif dan menarik untuk menghadirkan pengalaman belajar yang lebih mendalam dan memikat bagi siswa.

Berikut adalah beberapa alasan mengapa pembelajaran interaktif dan pengenalan VR sebagai alat pembelajaran yang inovatif penting:

1. Meningkatkan Keterlibatan dan Motivasi Siswa: Dengan memungkinkan siswa untuk berinteraksi langsung dengan konten pembelajaran melalui pengalaman VR yang imersif, pembelajaran menjadi lebih menarik dan memikat. Siswa merasa lebih terlibat dalam proses belajar, yang pada gilirannya dapat meningkatkan motivasi mereka untuk belajar lebih lanjut.
2. Pemahaman Konsep yang Lebih Mendalam: Melalui penggunaan VR, siswa dapat mengalami konsep-konsep abstrak atau sulit dipahami secara langsung. Mereka dapat menjelajahi lingkungan 3D, mengobservasi objek atau fenomena dalam skala yang lebih nyata, dan melakukan simulasi interaktif. Hal ini membantu siswa memperoleh pemahaman yang lebih mendalam dan memperkuat konsep-konsep yang diajarkan.
3. Pembelajaran Berbasis Pengalaman: VR memungkinkan siswa untuk belajar melalui pengalaman langsung, yang dapat meningkatkan retensi informasi dan pemahaman mereka. Siswa dapat berpartisipasi dalam simulasi, eksperimen, atau situasi dunia nyata yang sulit diakses dalam pembelajaran konvensional. Mereka dapat melihat, merasakan, dan berinteraksi dengan lingkungan yang direpresentasikan secara virtual.
4. Kolaborasi dan Komunikasi: VR juga memungkinkan siswa untuk berkolaborasi dalam ruang virtual yang sama. Mereka dapat berinteraksi dengan sesama siswa atau guru, berbagi pengetahuan, dan bekerja sama untuk menyelesaikan tugas atau masalah. Hal ini memperkuat kemampuan komunikasi dan kerja tim siswa, serta mempersiapkan mereka untuk kehidupan dan pekerjaan di dunia yang semakin terhubung.
5. Pengayaan Pengalaman Pembelajaran: Dalam beberapa kasus, pengalaman yang dihadirkan melalui VR dapat memberikan kesempatan yang tidak mungkin dilakukan dalam konteks pembelajaran tradisional. Misalnya, siswa dapat mengunjungi tempat-tempat bersejarah yang jauh atau menyelami dunia bawah laut tanpa meninggalkan ruang kelas. Ini memperkaya pengalaman pembelajaran mereka dan membuka wawasan baru.

Pembelajaran interaktif dan pengenalan VR sebagai alat pembelajaran yang inovatif membawa banyak manfaat dan potensi untuk mengubah cara kita belajar dan mengajar. Dengan memanfaatkan teknologi VR dengan baik, pendidikan dapat menjadi lebih menarik, relevan, dan memberikan pengalaman pembelajaran yang lebih baik bagi siswa.

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ENHANCING ELEMENTARY SCHOOL STUDENTS' ENVIRONMENT AWARENESS THROUGH VIRTUAL REALITY BASED IMMERSIVE LEARNING EXPERIENCES

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Abstract

This study aimed to investigate the potential of virtual reality (VR) technology in enhancing environmental awareness among elementary school students. The theme was focused on animals in their natural habitat to provide an immersive learning experience. The method involves designing and implementing a VR-based curriculum for a group of fifth-grade students in Yogyakarta, Indonesia, using the Meta Quest 2 (formerly the Oculus Quest 2) and student worksheet developed with a Problem-Based Learning model. The curriculum includes interactive modules that allow students to explore different animal habitats and engage in virtual field trips to wildlife reserves. The VR environment allowed students to explore different animal habitats and engage in virtual field trips to wildlife reserves. The results show that the VR has potential effect on students' environment awareness, as well as their engagement and interest in learning about the natural world. This study suggests that the use of VR technology in elementary school classrooms has the potential to enhance students' learning experiences, promote environment awareness, and inspire future generations to become responsible stewards of the planet.

Keywords: Virtual reality, elementary schools, environment awareness, animal habitats, immersive learning experience.

1 INTRODUCTION

Virtual reality (VR) technology can revolutionise how we learn and experience the world around us. In recent years, educators have explored using VR in the classroom to create immersive learning experiences that engage students and enhance their understanding of complex concepts [1]–[3]. VR in education is still in its infancy, and new applications and methods for using the technology are being developed constantly. As VR technology continues to evolve and become more accessible, educators and researchers will have the opportunity to explore new ways of using it to enhance student learning and engagement. It makes it an exciting area of research with considerable potential for innovation and discovery [4]–[6].

The research novelty of using VR in education lies in its potential to create immersive and engaging learning experiences beyond what can be achieved through traditional teaching methods [7], [8]. VR technology allows students to explore and interact with complex concepts and environments that would otherwise be difficult or impossible to experience in the classroom. This approach is still a relatively new field, and much research is needed to understand its potential benefits and limitations fully [9]–[11]. However, the study mentioned in the article provides evidence of the positive impact that VR can have on students' environmental awareness and engagement.

The impact of VR usage on the learning experience can be significant. VR technology can create immersive and engaging learning experiences that help students better understand complex concepts and environments [12], [13]. VR captures students' attention and make learning more fun and interactive. It can create a sense of presence and involvement, making students feel like they are a part of the learning experience. Research has shown that VR can improve retention rates by providing students with a more memorable and engaging learning experience [14]. VR helps students visualize and interact with abstract concepts, making them easier to remember. VR creates personalized learning experiences tailored to individual students' needs and interests [7], [15]. It helps keep students engaged and motivated and provides them with a more effective learning experience. The impact of VR usage on the learning experience is positive, with the potential to enhance engagement, retention, understanding, personalization, and accessibility. However, it is essential to note that the effectiveness of VR in education is still being studied, and it is necessary to use it appropriately and thoughtfully to maximize its benefits.

The study focused on animals in their natural habitat, using VR technology to provide an immersive learning experience for fifth-grade students. The curriculum included interactive modules that allowed students to explore different animal habitats and engage in virtual field trips to wildlife reserves. The study aimed to investigate the potential of VR technology in enhancing environmental awareness among elementary school students. The goal was to promote environmental awareness and inspire future generations to become responsible stewards of the planet.

2 METHODOLOGY

The study aimed to investigate the potential of VR technology in enhancing environmental awareness among elementary school students. The researchers designed and implemented a VR-based curriculum for fifth-grade students to achieve this. The method involved using The Meta Quest 2 (formerly the Oculus Quest 2) VR headset and student worksheets. This study was conducted on upper elementary school students (4^{th} and 5^{th} grades) at a public elementary school in Yogyakarta, Indonesia.

The VR-based curriculum consisted of interactive modules that allowed students to explore different animal habitats and engage in virtual field trips to wildlife reserves. The students wore The Meta Quest 2 VR headset, which provided an immersive and engaging experience. The headset was preloaded with educational VR content designed to support the curriculum.

The curriculum was delivered over the course, with students engaging in VR-based learning activities during their regular class time. The curriculum was designed to be interactive, with students actively participating in the learning experience through exploration and engagement with the virtual environment. In addition, the student worksheets were developed using the Problem-Based Learning (PBL) model. This model is a student-centred approach to learning that encourages students to actively engage in the learning process by identifying and solving real-world problems.

The worksheet activities were designed to guide students through the PBL process, which involved several stages, including problem orientation, problem organization, investigation, analysis, and evaluation of problem solutions. Each stage of the PBL process was carried out by students in groups, allowing for collaborative learning and the development of problem-solving skills. Using the PBL model in conjunction with the VR-based curriculum, students applied what they learned in the virtual environment to real-world scenarios and developed a deeper understanding of the material. The combination of VR technology and the PBL model provided an engaging and practical learning experience for the students, promoting active learning and problem-solving skills. This worksheet was designed to encourage students to reflect on their learning experiences and to apply their knowledge to real-world scenarios. The students completed the worksheets during and after the completion of the VR-based curriculum.

3 RESULTS

3.1 Learning Preparation

To ensure that students could fully benefit from the VR-based curriculum, they were given an introductory session to familiarize themselves with the VR technology (See Figure 1). During this session, the teacher guided the students through operating The Meta Quest 2 VR headset, such as how to put it on properly, adjust the settings, and navigate through the menus. Furthermore, the teacher explained to the students how to use the provided student worksheets. The worksheets were designed to help students reflect on their learning experiences and apply what they learned to real-world scenarios. The teacher instructed the students to complete the worksheets as they progressed through the VR-based curriculum. By providing an introductory session and instructions on using the student worksheets, the teacher ensured that the students were prepared to fully engage in the VR-based learning activities and maximise the experience.

Figure 1. Preparation activities: Introductory session

3.2 Learning Activities

Students were grouped and assigned activities during the learning sessions according to their respective worksheets (See Figure 2). Each student was allowed to use The Meta Quest 2 VR headset to explore and engage with the virtual animal habitats. The VR-based curriculum covered various topics related to animals, such as their habitats, movements, physical characteristics, sounds, and accompanying text explanations. The VR technology allowed students to move freely between different animal habitats and observe them at their own pace.

Figure 2. Working on group following the worksheet

The observations made by the students during their VR-based exploration were then used to complete the worksheet activities. These activities were designed to help students reflect on their observations, deepen their understanding of animal habitats, and apply what they learned to real-world scenarios.

By working in groups and engaging with the VR-based curriculum, students learned in a more immersive and interactive way. The VR technology provided a unique and engaging learning experience that allowed students to explore and observe animal habitats in ways that would not have been possible with traditional classroom methods. Overall, using VR technology in the classroom gave students a more engaging and practical learning experience.

3.3 Learning Outcome

The figure shows that students described the characteristics of animals after engaging in VR-based observations. VR technology allowed students to immerse themselves in virtual animal habitats, making it easier for them to observe and understand the physical characteristics and behaviours of the animals. Figure 3 and Figure 4 describe the activity to identify the animal characteristics. They write it after observing in the VR.

Figure 3. The assignment to identify the animal characteristics after using VR

Figure 4. Student answer based on the observation in the VR

During this learning experience, students discovered new vocabulary words related to animal characteristics and habitats they had not previously encountered. It helped to reinforce their understanding of animals and their environments (See Figure 5 left). Furthermore, through the PBL model, students were encouraged to identify various problems related to wildlife conservation and develop alternative solutions from their perspectives (See Figure 5 right). It allowed them to think critically about the impact of human activities on the environment and create a sense of responsibility towards protecting and preserving wildlife.

Figure 5. The others student's outcome: new vocabulary and finding the solustions

The combination of VR technology and the PBL model provided a unique learning experience that enhanced students' knowledge of animals and their habitats and developed their critical thinking and problem-solving skills. By empowering students to take an active role in environmental conservation, this learning experience has the potential to inspire future generations to become responsible and environmentally conscious global citizens.

4 DISCUSSION

The results showed the improvement in students' environmental awareness, engagement, and interest in learning about the natural world. The students who participated in the VR-based curriculum showed a deeper understanding of environmental issues and were more likely to express a desire to protect the planet. Through the use of VR-based observations and accompanying worksheet activities, students

were able to deepen their knowledge and understanding of animal habitats. The combination of VR technology and the PBL model provided a practical learning experience that allowed students to apply what they learned in the virtual environment to real-world scenarios. The results suggest that the use of VR technology in the classroom has the potential to enhance student's learning experiences and promote environmental awareness. By providing an immersive and engaging learning experience, VR technology inspires future generations to become responsible stewards of the planet.

The use of VR technology in the classroom has several advantages. It allows students to experience environments and concepts that may be difficult or impossible to replicate in a traditional classroom setting [16], [17]. It helps to create a more engaging and immersive learning experience that captures students' attention and motivates them to learn [12]. VR technology created simulations that allow students to experiment with complex ideas and concepts in a safe and controlled environment.

The use of VR technology in the classroom has its challenges. One of the main concerns is the cost of implementing VR technology in schools. VR headsets and other equipment can be expensive, and not all schools have the resources to invest in this technology. Additionally, there may be concerns about the potential for distraction or disorientation when using VR technology, which could lead to reduced learning outcomes. Despite these challenges, this study's results suggest that using VR technology in elementary school classrooms enhanced students' learning experiences, promote environmental awareness, and inspire future generations to become responsible stewards of the planet. As technology continues to develop and become more accessible, more and more schools will likely begin incorporating VR into their curricula [18]–[20]. It has the potential to transform education and help prepare students for the challenges of the 21st century.

The results of this study can be explained using several educational theories. The combination of constructivist, social constructivist, and experiential learning theories provided a robust framework for creating compelling and engaging learning experiences using VR technology in the classroom. The use of VR technology in this study aligns with the principles of constructivism, which posits that learners construct their understanding of the world based on their experiences and interactions with their environment [1], [21]. Through the immersive and interactive learning experience VR technology provides, students actively engage with the material and construct their knowledge of animal habitats and conservation.

The use of the PBL model aligns with the principles of social constructivism, which emphasizes the importance of social interaction and collaboration in learning. Through working collaboratively in groups, students could share their ideas, build on each other's knowledge, and develop a shared understanding of the problems and solutions related to wildlife conservation [22], [23]. The results of this study can be explained using the concept of experiential learning, which suggests that learning occurs through a cycle of concrete experiences, reflective observation, abstract conceptualization, and active experimentation [24], [25]. Through the VR-based observations and accompanying worksheet activities, students could engage in each stage of this cycle, from experiencing the virtual animal habitats firsthand to reflecting on their observations to applying their knowledge to real-world problems.

5 CONCLUSIONS

This study highlights the potential of VR technology to enhance environmental awareness among elementary school students. By designing and implementing a VR-based curriculum focused on animal habitats, the study demonstrated that students could improve their knowledge and attitudes towards the natural world. The results showed that students could engage with the material, learn new vocabulary, identify problems related to wildlife conservation, and propose alternative solutions. The use of VR technology in the classroom has the potential to provide an immersive and interactive learning experience that can enhance students' engagement, interest, and understanding of complex concepts related to the environment. As educators continue to explore the potential of VR technology in the classroom, further research is needed to assess the long-term impact of VR-based learning on student achievement and engagement. Nonetheless, this study provides a promising indication of the potential of VR technology to promote environmental awareness and inspire future generations to become responsible stewards of the planet.

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Application of Cognitive Load Theory in VR Development and Its Impact on Learning: A Perspective on Prior Knowledge, Learning Interest, Engagement, and Content Comprehension

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Keywords: cognitive load theory, content comprehension, engagement, learning interest, prior knowledge, virtual reality

Abstract

This research examines the utilization of Virtual Reality (VR) and its implications for the learning process, specifically focusing on learning interest, prior knowledge, learning engagement, and content comprehension. The central objective is to establish a comprehensive model that unravels the intricate interplay between these factors within the context of VR-based learning. The study also aims to shed light on the impact of integrating Cognitive Load Theory into VR development and its effects on the learning experience. Adopting an observational design, this study elucidates the intricate relationships among learning interest, prior knowledge, learning engagement, and content comprehension in VR-based education. The VR technology employed in this research has previously undergone rigorous feasibility testing. The VR application was designed following cognitive load theory principles. Its immersive content offers users a lifelike immersion into the natural habitats of diverse animal species across various global regions. By leveraging VR technology, elementary school students engage in a more profound and authentic learning journey. A total of 85 participants, encompassing fourth and fifth-grade elementary school students, were involved in the study. These students were drawn from schools situated in rural areas in particular regions in Indonesia with moderate to low economic backgrounds. The variables under examination include Prior Knowledge, Learning Interest, Engagement, and Content Comprehension as learning outcomes. Data analysis was conducted utilizing a blend of linear regression and path analysis techniques, with a confidence level of 95%. The Guttman scale questionnaire was used, and total scores were transformed into a ratio scale through a conversion process. The study reveals a positive correlation between learning interest and learning outcomes, highlighting that a strong interest in a subject contributes to improved learning results. Additionally, both learning interest and prior knowledge influence learning engagement. Students with higher learning interests and prior knowledge are more likely to actively engage in the learning process, underscoring internal factors' role in motivating participation. Learning engagement is a moderating factor in the relationships between learning interest, prior knowledge, and learning outcomes. By enhancing the effect of learning interest and prior knowledge on learning outcomes, engagement enables more comprehensive and practical information processing.

1 Introduction

Education has become a battleground for unstoppable technological innovation. Advances in technology have provided promising new opportunities to enrich the learning experience. One intriguing innovation that has captured attention is the development of Virtual Reality (VR). VR is a technology that enables individuals to "immerse" themselves in digitally created worlds, crafting immersive experiences that merge visual, auditory, and often kinesthetic elements(Bacca-Acosta et al., 2022; O'Connor & Worman, 2019). The potential of VR in creating deep and immersive learning experiences is captivating. With VR, students can directly engage with subject matter, observe complex phenomena from various perspectives, and interact within virtual environments (Dreimane, 2019; Pellas et al., 2020).

However, while VR technology offers enticing prospects, it is crucial to remember that the effectiveness of education is not solely determined by the tools or technology employed. This is where Cognitive Load Theory becomes pivotal. Cognitive Load Theory helps us comprehend the extent of the mental "load" students encounter during the learning process (Andersen et al., 2016; Ayres, 2020; Van Merrienboer & Sweller, 2005). This encompasses the complexity of learning materials (intrinsic load), how materials are presented (extrinsic load), and the mental effort invested in integrating information (germane load) (Ayres, 2020). In developing VR applications for learning, it is imperative to consider how this technology might influence cognitive load. While immersive learning experiences can enhance content comprehension, processing information within a VR environment may also demand increased mental effort (Armougum et al., 2019; Tabbers et al., 2004). This can impact student motivation and even cognitively burden them, diminishing the learning process's effectiveness.

Therefore, developing education applications is more than just about creating visually impressive environments; it also concerns optimizing the learning experience by minimizing excessive cognitive load. Integrating Cognitive Load Theory into the design of VR applications will enable developers to identify points that require simplification or more structured approaches. By attending to these factors, VR technology can yield more effective learning outcomes, prevent cognitive fatigue, and maintain the requisite immersion. Rapid technological changes, especially in computing and graphics, have transformed the education paradigm remarkably. One particularly compelling innovation in this context is the development of VR (Armougum et al., 2019; Liu et al., 2020; Parong & Mayer, 2018; Xu & Ke, 2016). VR introduces new possibilities to the learning experience by altering how students interact with information and learning content.

Alongside the promised potential of VR, some challenges need to be addressed to maximize its effectiveness within the educational context. This is where Cognitive Load Theory plays a crucial role. Cognitive Load Theory seeks to comprehend the extent of an individual's mental "load" during the learning and thinking processes. This load can encompass various factors influencing information processing, cognitive resource utilization, and learning outcomes.

Applying Cognitive Load Theory concepts in developing VR for education carries significant implications. An effective VR environment should alleviate the excessive cognitive load on students (Tabbers et al., 2004; Van Merrienboer & Sweller, 2005). By optimizing material complexity, transparently presenting information, and designing interactions that facilitate content comprehension, VR development can create more effective and meaningful learning experiences. The influence of Cognitive Load Theory on student motivation cannot be ignored. When students feel cognitively burdened, their motivation to learn can diminish. Hence, VR development must balance material

complexity and students' capacity to cope with this load while maintaining enthusiasm in the learning process.

This research aims to investigate the application of VR and its impact on the learning process, focusing on learning interest, prior knowledge, learning engagement, and content comprehension. Specifically, this research aims to establish a model to elucidate the interrelationships among learning interest, prior knowledge, learning engagement, and content comprehension in VR-based learning. This study is expected to provide a better understanding of how the utilization of Cognitive Load Theory in VR development can influence the learning process.

2 Literature Review

Cognitive Load Theory is a framework utilized to understand how the mental or cognitive load experienced by an individual can impact information processing, learning, and task performance. This theory delineates how the human mind is limited to processing information within short-term memory (working memory) (Ayres, 2020). In the context of Information and Communication Technology (ICT) utilization, such as software applications, online learning platforms, and immersive technologies like VR, Cognitive Load Theory holds significant implications concerning the efficiency of comprehension and technology utilization (Albus et al., 2021; Armougum et al., 2019; Castro-Alonso & de Koning, 2020). Within the realm of ICT, intrinsic load refers to the complexity of material or information presented through technology (Castro-Alonso & de Koning, 2020). For instance, dense material or intricate concepts can elevate the intrinsic load in online learning. Therefore, interface design and content presentation should consider how information is conveyed for easier digestion. Extrinsic Load pertains to how information is presented through technology. The extrinsic load can increase if the interface is non-intuitive, the navigation needs to be easier to grasp, or the layout needs to be more apparent. In ICT utilization, it's crucial to design user-friendly interfaces, reduce extrinsic load, and enable easy access to information (Frederiksen et al., 2020; Haryana et al., 2022). In the context of ICT, germane load involves the mental effort required to comprehend and connect new information with existing knowledge. ICT utilization can be enhanced by providing clear context and linking new concepts to prior content. Technology can be harnessed to create interactions that encourage more profound understanding. By grasping the elements of Cognitive Load Theory, ICT developers and designers can craft solutions that are more adaptive and responsive to user needs and capabilities (Castro-Alonso & de Koning, 2020).

The development of VR has brought about a paradigm shift in education. VR technology enables users to interact with highly realistic, visually immersive environments, often accompanied by audio elements (Bogusevschi et al., 2020; Martín-Gutiérrez et al., 2017; Xu & Ke, 2016). Within the educational context, VR creates deep and immersive learning experiences, allowing students to "dive into" abstract concepts, distant locations, or situations challenging to simulate within traditional classrooms (Shafer et al., 2019). VR in education holds tremendous potential to transform how we learn, teach, and understand the world around us. VR enables students to engage with lessons more profoundly and tangibly. They can explore 3D structures, observe intricate processes in action, or grasp complex concepts more visually (Bogusevschi et al., 2020; Lin et al., 2017; Sulisworo et al., 2022). With VR, students can partake in realistic simulations of scientific experiments, aviation scenarios, or historical recreations. This aids students in comprehending concepts more practically and interacting with environments otherwise inaccessible in real life. The immersive and enjoyable learning experiences offered by VR can boost student motivation. They become more likely to actively engage with learning as it introduces elements of gamification and exploration (Shafer et al., 2019; Xu & Ke, 2016). Through 3D visualizations and interactions, students can gain a better grasp of abstract concepts.

VR allows them to "see" concepts from various angles, reinforcing their understanding. It's essential to approach the use of VR in education with caution. Virtual learning should be different from real-world social interaction and hands-on experiences. Hence, VR integration must combine diverse learning strategies to achieve optimal learning outcomes (Chang et al., 2020; Cheng & Tsai, 2020). By combining the potential of VR with established teaching methods, education can leverage this technology to shape more meaningful and compelling learning experiences for students.

Numerous studies have delved into the correlation between learning interest and learning outcomes. Motivational theories, such as intrinsic and extrinsic motivation, are often employed to elucidate how learning interest can impact students' engagement levels and learning outcomes (Carbonell-Carrera & Saorín, 2017; Cheng & Tsai, 2020). These investigations frequently indicate that students with a heightened interest in a subject tend to achieve better learning outcomes. Literature concerning prior knowledge and learning outcomes often centers on how students' preexisting knowledge can influence their aptitude for comprehending new concepts (Chen & Liao, 2022; Makransky et al., 2019; Trust et al., 2021). Constructivist and transfer learning theories frequently serve as the foundation to explore how prior knowledge shapes the learning process and its eventual outcomes.

Research also frequently considers the role of learning engagement as a factor influencing the relationship between learning interest, prior knowledge, and learning outcomes (Pilgrim & Pilgrim, 2016; Taçgın, 2020). Concepts of information and cognitive processing are frequently harnessed to expound on how learning engagement can moderate these relationships. Learning engagement may act as a mediator or enhancer in the interaction among these variables (Bennett & Saunders, 2019; Huang et al., 2021; Trust et al., 2021). Studies that involve a combination of variables—learning interest, prior knowledge, learning engagement, and learning outcomes—can shed light on the intricate dynamics of the learning process (Annetta et al., 2009; Flavián et al., 2021; Mouatt et al., 2020). Motivation, cognition, and learning theories may be employed to comprehend how the interplay of these variables shapes students' learning experiences.

Learning interest and engagement are related concepts in education, but they refer to different aspects of a learner's experience. Learning interest refers to an individual's curiosity, attraction, or desire to explore and acquire knowledge about a particular subject or topic. When a person has a strong learning interest in a subject, they are more likely to actively seek out information, participate in discussions, and invest time and effort in understanding the material. Learning interest is the individual's internal inclination or desire to learn about a specific topic. On the other hand, engagement is the level of attention, enthusiasm, and interaction a learner exhibits during an educational activity. While learning interest is more about personal motivation, engagement reflects the learner's responsiveness to the learning environment. Engagement encompasses active involvement and interaction with the learning process.

Both learning interest and engagement are essential considerations when designing a virtual reality (VR) system based on cognitive load principles. Designing a VR system that aligns with learners' interests can enhance motivation and willingness to engage with the content. When individuals are interested in the subject, their intrinsic motivation can help mitigate the perceived cognitive load. Incorporating content that resonates with users, addresses their curiosity, and aligns with their preferences can contribute to a more positive learning experience in VR. At the same time, high levels of engagement can positively impact cognitive load management. When users actively engage in a VR learning experience, they are more likely to allocate cognitive resources effectively, improving retention and understanding of the material. Interactive and immersive elements within the VR system can promote engagement. Well-designed scenarios, simulations, and activities

encouraging active participation can provide a more effective learning experience. A successful VR system based on cognitive load principles should consider the cognitive aspects and learners' interests and engagement levels. By doing so, designers can create a more immersive and compelling learning experience that optimizes cognitive load and promotes meaningful learning outcomes.

3 Methods

3.1 Research Context

This study employs an observational design to explore a model that can elucidate the interconnections between learning interest, prior knowledge, learning engagement, and content comprehension in VR-based learning. The VR utilized in this research has undergone feasibility testing in previous studies (Sulisworo et al., 2022, 2023). This VR was developed with the application of cognitive load theory. The VR content immerses users in the lifelike depiction of animals and their natural habitats across various regions worldwide. This application enables elementary school students to explore the authentic habitats of animals realistically through VR technology. Through VR, students undergo a more profound and immersive learning experience. The study participants comprised 85 elementary school students from both fourth and fifth grades. They hail from schools located in economically moderate to low-income rural areas.

Applying Cognitive Load Theory in developing learning media with Virtual Reality (VR) involves several steps and special considerations such as identifying learning objectives, introducing users (target audience), optimizing intrinsic and extrinsic cognitive load, interactive experience design, optimizing germane cognitive load, and feedback in real-time. Determine clear and specific learning objectives, namely recognizing various animals' characteristics and way of life in their habit—design VR experiences by considering learners' level of knowledge and skills. Elementary school students need to be given an animal environment that still uses concrete concepts (sound, movement, shape). Optimizing Intrinsic Cognitive Load ensures that the content arouses interest and intrinsic motivation to learn. The content is related to various animals that are not always present in their everyday environment, thereby allowing for higher interest. Minimizing Extrinsic Cognitive Load is done by simplifying the VR user interface reducing visual distractions or unnecessary information. In the VR used, the interface is simple with just moving (left, right, forward, backward) and direction buttons. There are no complex features in the application created—interactive Experience Design by utilizing the advantages of VR in providing interactive experiences and presenting information in depth. The application design is made like an adventure in various animal habitats accompanied by relevant information to provide an excellent interactive experience. Optimizing the use of Germane Cognitive Load is carried out by choosing teaching methods to form good cognitive schemes. Various types of animals with different habitats allow the presentation of information from previous knowledge to the ability to understand new knowledge. Real-Time Feedback is carried out by utilizing VR capabilities to provide direct feedback. Real-time feedback can be obtained by comparing experiences observing animal life with information boards explaining the animal's characteristics.

3.2 Variables

The variables measured in this study encompass several aspects, namely:

- Prior Knowledge (PRK): Assessing how students possess prior knowledge concerning animal life and their habitats.

- Learning Interest (INT): Gauging the level of students' motivation in learning before utilizing VR.
- Engagement (ACT): Measuring the degree of students' engagement during learning through VR.
- Content Comprehension as learning outcomes (LEP): Evaluating the extent to which students comprehend the learning content related to animal life and their habitats after using VR.

Before the learning session commences, participants' learning interests and prior knowledge are measured. Following this, they engage in learning using the VR application. Throughout the learning process, observation is conducted, and the student's engagement levels are quantified. After the learning session, students are measured again to gauge their understanding of the material acquired during the VR-based learning.

Students explore the zoo by observing the animals. Each animal is designed to be in its natural habitat. To observe these animals, users walk on the existing track with directions for the position of each animal. Animals can be approached for more details (sounds and movements). Users can search for more detailed information by pressing the information button to display an information board in text form.

3.3 Instruments

Data for this study were collected through a Guttman scale questionnaire for learning interest and engagement. Additionally, prior knowledge and content comprehension were measured using multiple-choice tests. In developing the instruments, the prior knowledge (PRK) assessment consisted of 15 multiple-choice questions covering comparisons (item number 1-5), categorizations (item number 6-10), and life pattern analysis (item number 11-15). Investigation revealed that only eight items were usable (PRK1, PRK2, PRK8, PRK9, PRK10, PRK11, PRK12, and PRK14).

For learning interest (INT), there were eight perceptual statement items encompassing enjoyment (item number 1,2), interest (item number 3,4), attention (item number 5,6), and involvement (item number 7,8). Analysis results indicated that only four items (INT1, INT5, INT6, and INT8) were usable.

There were six observational items for learning engagement (ACT): task completion, asking questions, participating in discussions, recording activity outcomes, seeking information, and self-assessment. Analysis showed that only five items (ACT1, ACT2, ACT4, ACT5, and ACT6) were usable.

For learning outcomes (LEP), data from a 15-item multiple-choice test covering comparisons (item number 1-5), categorizations (item number 6-10), and life pattern analysis (item number 11-15) were used. Analysis results found that only eight items were usable (LEP4, LEP7, LEP8, LEP9, LEP11, LEP12, LEP14, and LEP15). See Table 1 for the statistic result.

Table 1. The item validity and reliability for each variable

Variable/ Item	Mean	STD	Correlation (r)	Alpha Cronbach
Prior Knowledge (PRK)				.683
PRK1	.8235	.38348	.441	
PRK2	.7765	.41908	.316	
PRK8	.6824	.46832	.226	

Variable/ Item	Mean	STD	Correlation (r)	Alpha Cronbach
PRK9	.7294	.44690	.425	
PRK10	.7294	.44690	.440	
PRK11	.7176	.45282	.521	
PRK12	.4824	.50265	.385	
PRK14	.5412	.50126	.393	
Learning Interest (INT)				
INT1	.5882	.49507	.284	
INT5	.7412	.44059	.426	.686
INT6	.8118	.39322	.430	
INT8	.6588	.47692	.526	
Learning Engagement (ACT)				
ACT1	.8235	.38348	.236	
ACT2	.9412	.23669	.302	.610
ACT4	.5059	.50293	.513	
ACT5	.6353	.48420	.383	
ACT6	.4588	.50126	.352	
Learning Outcome (LEP)				
LEP4	.8824	.32410	.285	
LEP7	.8588	.35027	.287	
LEP8	.8588	.35027	.314	
LEP9	.8235	.38348	.402	.207
LEP11	.8706	.33765	.215	
LEP12	.9059	.29373	.230	
LEP14	.8941	.30951	.318	
LEP15	.8000	.40237	.308	

3.4 Analysis Technique

A combination of linear regression analysis and path analysis techniques was employed to analyse the obtained data. The level of confidence was 95%. For the Guttman scale questionnaire, total scores were derived by converting the scores into a ratio scale. The conversion involved summing the scores of each item and dividing by the total possible score, then multiplying by 100 per cent. The path analysis model tested can be observed in Figure 1. SPSS software was applied for this analysis.

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SURAT PENCATATAN CIPTAAN

Dalam rangka pelindungan ciptaan di bidang ilmu pengetahuan, seni dan sastra berdasarkan Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta, dengan ini menerangkan:

Nomor dan tanggal permohonan	:	EC002023127242, 8 Desember 2023
Pencipta		
Nama	:	**Prof. Dr. Ir. Dwi Sulisworo, MT., Vera Yuli Erviana dkk**
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Kewarganegaraan	:	Indonesia
Pemegang Hak Cipta		
Nama	:	**UNIVERSITAS AHMAD DAHLAN**
Alamat	:	Jl. Pramuka 5F, Pandeyan, Umbulharjo, Yogyakarta, Di Yogyakarta 55161
Kewarganegaraan	:	Indonesia
Jenis Ciptaan	:	**Buku**
Judul Ciptaan	:	**Model Pembelajaran Berbasis Problem Based Learning Berbantuan Virtual Reality Untuk Peningkatan HOTS Siswa**
Tanggal dan tempat diumumkan untuk pertama kali di wilayah Indonesia atau di luar wilayah Indonesia	:	7 Desember 2023, di Yogyakarta
Jangka waktu pelindungan	:	Berlaku selama 50 (lima puluh) tahun sejak Ciptaan tersebut pertama kali dilakukan Pengumuman.
Nomor pencatatan	:	000560197

adalah benar berdasarkan keterangan yang diberikan oleh Pemohon.
Surat Pencatatan Hak Cipta atau produk Hak terkait ini sesuai dengan Pasal 72 Undang-Undang Nomor 28 Tahun 2014 tentang Hak Cipta.

a.n. MENTERI HUKUM DAN HAK ASASI MANUSIA
Direktur Hak Cipta dan Desain Industri

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MODEL PEMBELAJARAN BERBASIS *PROBLEM BASED LEARNING* BERBANTUAN *VIRTUAL REALITY*

UNTUK PENINGKATAN HOTS SISWA

Vera Yuli Erviana, Dwi Sulisworo, Bambang Robi'in, Eva Rismawati N. A.

MODEL PEMBELAJARAN BERBASIS *PROBLEM BASED LEARNING* BERBANTUAN *VIRTUAL REALITY*
untuk Peningkatan *HOTS* Siswa

Vera Yuli Erviana, M.Pd.
Dwi Sulisworo
Bambang Robi'in
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Penerbit K-Media
Yogyakarta, 2022

MODEL PEMBELAJARAN BERBASIS *PROBLEM BASED LEARNING* BERBANTUAN *VIRTUAL REALITY* UNTUK PENINGKATAN *HOTS* SISWA

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peraturan yang terus menerus terjadi. Penyusun menyadari bahwa buku ini masih sangat jauh dari kesempurnaan baik dari bentuk penyusunan maupun materinya. Saran dari pembaca sangat penyusun harapkan untuk penyempurnaan buku ini selanjutnya. Akhir kata, semoga buku ini dapat memberikan manfaat kepada para guru sekolah dasar.

Yogyakarta, September 2022

Penyusun

DAFTAR ISI

yang efektif dalam membantu terjadinya proses belajar.

Pada proses pembelajaran, media pengajaran merupakan wadah dan penyalur pesan dari sumber pesan, dalam hal ini guru, kepada penerima pesan, dalam hal ini siswa. Dalam batasan yang lebih luas, Yusufhadi Miarso memberikan batasan media pengajaran sebagai segala sesuatu yang dapat digunakan untuk merangsang pikiran, perasaan, perhatian, dan kemauan siswa sehingga mendorong terjadinya proses belajar pada diri siswa.

Apabila dilihat dari manfaatnya Ely dalam Danim menyebutkan manfaat media dalam pengajaran adalah sebagai berikut: (a) Meningkatkan mutu pendidikan dengan cara meningkatkan kecepatan belajar (rate of learning), (b) Memberi kemungkinan pendidikan yang sifatnya lebih individual, (c) Memberi dasar pengajaran yang lebih ilmiah, (d) Pengajaran dapat dilakukan secara mantap, (e) Meningkatkan terwujudnya kedekatan belajar (immediacy learning), dan (f) Memberikan penyajian pendidikan lebih luas. 4 Selain itu, dari

kekuatan Virtual Reality dalam meyakinkan pengguna dan meyakinkan kehadiran mereka di dalam lingkungan buatan (Wittenberg, 1993). Virtual Reality juga menawarkan lingkungan interaktif yang melibatkan peserta didik dan memungkinkan mereka memvisualisasikannya. Teknologi ini diperkenalkan sebagai alat inovasi untuk memecahkan masalah kompleks, sehingga menghasilkan solusi yang unik, realistis dan praktis bagi peserta didik (Kartiko et al, 2010). Penelitian dari seorang guru sains bernama Winn and Bricken yang menggunakan Virtual Reality untuk menjelaskan materi matematika abstrak menyimpulkan bahwa Virtual Reality memiliki potensi meningkatkan cara belajar peserta didik secara signifikan (Winn & Bricken, 1992). Demikian juga penelitian dari Moses yang menggunakan Virtual Reality dalam menganalisis vektor dan geometri deskriptif, menunjukkan bahwa peserta didik menilai Virtual Reality sebagai tempat eksperimen yang sangat baik dan dapat berpikir lebih mudah untuk memahami konsep materi tersebut (Okechukwu & Eze, 2011).

b. Augmented Reality

Augmented Reality merupakan aplikasi penggabungan dunia nyata dengan dunia maya dalam bentuk dua dimensi maupun tiga dimensi yang diproyeksikan dalam sebuah lingkungan nyata dalam waktu yang bersamaan. Augmented Reality sering juga disebut dengan realitas tertambat. Aplikasi ini sering diterapkan dalam sebuah game. Seperti yang dilansir dari inet.detik.com (2015) menyebutkan bahwa Xbox Development dari Microsoft tidak hanya menghadirkan game dalam bentuk Virtual Reality namun juga menghadirkan game dalam bentuk Augmented Reality. Teknologi yang masih tergolong baru ini masih sedikit pemanfaatannya di Indonesia. Dilansir dari republika.co.id (2015) menyebutkan bahwa penggunaan Augmented Reality di Indonesia belum terlalu besar. Masih minimnya pengetahuan masyarakat mengenai teknologi ini menjadi salah satu penyebabnya. Dengan menggunakan Augmented Reality sebagai salah satu alternatif media pembelajaran, diharapkan dalam sebuah kegiatan pembelajaran dapat lebih

menarik bagi siswa. Manfaat lain yang diperoleh adalah media pembelajaran yang lebih maju dengan memanfaatkan perkembangan teknologi saat ini. Melalui Augmented Reality dapat menjadi salah satu solusi untuk mengatasi modul. Berbeda dengan Virtual Reality (VR) yang menambahkan obyek nyata pada sebuah obyek maya, Augmented Reality (AR) adalah menambahkan obyek maya ke dalam obyek nyata dalam waktu yang bersamaan. Menurut Raajan (2014) menyebutkan bahwa Augmented Reality pertama kali digunakan pada tahun 1957-1962 oleh seorang sinematografer bernama Norton Heilig, yang diberi nama Sensorama. Sensorama merupakan sebuah simulator yang dapat mensimulasikan visual, getaran, dan bau.

C. Manfaat Media Pembelajaran

Hamalik (1986) mengemukakan bahwa pemakaian media pengajaran dalam proses belajar mengajar dapat membangkitkan keinginan dan minat yang baru, membangkitkan motivasi dan rangsangan kegiatan belajar, dan bahkan membawa pengaruh-pengaruh psikologis terhadap siswa.

Secara umum, manfaat media dalam proses pembelajaran adalah memperlancar interaksi antara guru dengan siswa sehingga pembelajaran akan lebih efektif dan efisien. Tetapi secara lebih khusus ada beberapa manfaat media yang lebih rinci Kemp dan Dayton (1985) misalnya, mengidentifikasi beberapa manfaat media dalam pembelajaran yaitu:

a. Penyampaian materi pelajaran dapat diseragamkan.
b. Proses pembelajaran menjadi lebih jelas dan menarik.
c. Proses pembelajaran menjadi lebih interaktif.
d. Efisiensi dalam waktu dan tenaga.
e. Meningkatkan kualitas hasil belajar siswa.
f. Media memungkinkan proses belajar dapat dilakukan dimana saja dan kapan saja.
g. Media dapat menumbuhkan sikap positif siswa terhadap materi dan proses belajar.
h. Merubah peran guru ke arah yang lebih positif dan produktif.

Selain beberapa manfaat media seperti yang dikemukakan oleh Kemp dan Dayton tersebut, tentu saja kita masih dapat menemukan banyak

manfaat-manfaat praktis yang lain. Manfaat praktis media pembelajaran di dalam proses belajar mengajar sebagai berikut:

a. Media pembelajaran dapat memperjelas penyajian pesan dan informasi sehingga dapat memperlancar dan meningkatkan proses dan hasil belajar.
b. Media pembelajaran dapat meningkatkan dan mengarahkan perhatian anak sehingga dapat menimbulkan motivasi belajar, interaksi yang lebih langsung antara siswa dan lingkungannya, dan kemungkinan siswa untuk belajar sendiri-sendiri sesuai dengan kemampuan dan minatnya.
c. Media pembelajaran dapat mengatasi keterbatasan indera, ruang dan waktu.
d. Media pembelajaran dapat memberikan kesamaan pengalaman kepada siswa tentang peristiwa-peristiwa di lingkungan mereka, serta memungkinkan terjadinya interaksi langsung dengan guru, masyarakat, dan lingkungannya misalnya melalui karya wisata. Kunjungan-kunjungan ke museum atau kebun binatang (Azhar Arsyad, 2007)

D. Fungsi Media Pembelajaran

Dalam proses pembelajaran, media pembelajaran memiliki beberapa fungsi. Wina sanjaya (2014) menjabarkan beberapa fungsi tersebut dalam beberapa jenis yaitu:

1. Fungsi komunikatif.

Media pembelajaran digunakan untuk memudahkan komunikasi antara penyampai pesan dan penerima pesan.

2. Fungsi motivasi.

Dengan menggunakan media pembelajaran, diharapkan siswa akan lebih termotivasi dalam belajar. Dengan demikian, pengembangan media pembelajaran tidak hanya mengandung unsur artistik saja akan tetapi juga memudahkan siswa mempelajari materi pelajaran sehingga dapat meningkatkan gairah belajar siswa.

3. Fungsi kebermaknaan.

Melalui penggunaan media, pembelajaran bukan hanya dapat meningkatkan penambahan informasi berupa data dan fakta sebagai pengembangan aspek kognitif tahap rendah, akan tetapi dapat meningkatkan kemampuan siswa

untuk menganalisis dan mencipta sebagai aspek kognitif tahap tinggi. Bahkan lebih dari itu dapat meningkatkan aspek sikap dan keterampilan.

4. Fungsi penyamaan persepsi.

Melalui pemanfaatan media pembelajaran, diharapkan dapat menyamakan persepsi setiap siswa, sehingga setiap siswa memiliki pandangan yang sama terhadap informasi yang disuguhkan.

5. Fungsi individualitas.

Pemanfaatan media pembelajaran berfungsi untuk dapat melayani kebutuhan setiap individu yang memiliki minat dan gaya belajar yang berbeda (Aghni 2018).

Daryanto (2013) juga memberikan penjelasan terkait beberapa kegunaan media pembelajaran yaitu :

1). Memperjelas pesan agar tidak terlalu verbalistis.

2) Mengatasi keterbatasan ruang, waktu, tenaga, dan daya indra.

3) Menimbulkan gairah belajar, interaksi lebih langsung antara siswa dengan sumber belajar.

4) Memungkinkan siswa belajar mandiri sesuai dengan bakat dan kemampuan visual, auditori, dan kinestetiknya.

5) Memberi rangsangan yang sama, mempersamakan pengalaman dan menimbulkan persepsi yang sama.

6) Proses pembelajaran mengandung lima komponen komunikasi, guru (komunikator), bahan pembelajaran, media pembelajaran, siswa (komunikan), dan tujuan pembelajaran (Aghni 2018).

3. Pembelajaran Berbasis HOTS

A. Pengertian HOTS

Pada abad ke-21 generasi-generasi muda memang sudah harus dibekali dengan beberapa kemampuan. Setidaknya ada 3 kemampuan yang harus dikuasai oleh generasi mudah saat ini, diantaranya kemampuan berfikir kritis, kemampuan berpikir kreatif, serta kemampuan dalam memecahkan suatu masalah (Pratiwi,2019:128). Ketiga kemampuan lebih dikenal atau kita sebut dengan kemampuan HOTS. Kemampuan-kemampuan tersebut

dibutuhkan dalam menyelesaikan masalah, sebab pesatnya perkembangan pengetahuan dan teknologi telah menghasilkan tantangan dan masalah yang akan dihadapi manusia di abad 21 menjadi lebih kompleks (Saraswati and Agustika 2020).

Menurut Saputra (2016) Higher Order Thinking Skills (HOTS) merupakan suatu proses berpikir peserta didik dalam level kognitif yang lebih tinggi yang dikembangkan dari berbagai konsep dan metode kognitif dan taksonomi pembelajaran seperti metode problem solving, taksonomi bloom, dan taksonomi pembelajaran, pengajaran, dan penilaian. Tujuan utama dari high order thinking skills adalah bagaimana meningkatkan kemampuan berpikir peserta didik pada level yang lebih tinggi, terutama yang berkaitan dengan kemampuan untuk berpikir secara kritis dalam menerima berbagai jenis informasi, berpikir kreatif dalam memecahkan suatu masalah menggunakan pengetahuan yang dimiliki serta membuat

keputusan dalam situasi-situasi yang kompleks (Wahyuningsih et al. 2009)

HOTS (Higher order thinking) pertama kali dikemukakan oleh seorang penulis sekaligus Associate Professor Dari Dusquance University bernama Susan M Brookhart dalam bukunya, 'How to Assess Higher-order Thinking Skills in Your Classroom' (2010). Dia mendefinisikan model ini sebagai metode untuk transfer pengetahuan, berpikir kritis, dan memecahkan masalah. HOTS tak sekedar model soal, tetapi juga mencangkup model pengajaran. Model pengajaran harus mencangkup kemampuan berpikir, contoh, pengaplikasian pemikiran dan diadaptasikan dengan kebutuhan siswa yang berbeda-beda. Ada pula model penilaian dari HOTS yang mengharuskan siswa tak familiar dengan pertanyaan atau tugas yang diberikan. Ini dimaksudkan agar siswa memiliki cukup pengetahuan awal untuk menggunakan kemampuan berpikir tingkat tinggi.Ada 3 format item dalam pengujian HOTS. Format itu adalah (a) seleksi,

termasuk pilihan ganda, mencocokkan, dan pemeringkatan; (b) umum, termasuk esai, jawaban singkat, dan tugas-tugas; (c) penjelasan, yang menuliskan alasan mengapa jawaban itu dipilih.Robyn Collins, dalam tulisannya berjudul 'Skills for the 21st Century: teaching higher-order thinking' yang dimuat dalam situs curriculum.edu.au(2014), HOTS bertujuan mempersiapkan masyarakat memasuki abad ke-21 (Ansori 2015).

Penjelasan oleh Budiarta (2018:103) menyebutkan HOTS dapat dimaknai sebagai kemampuan proses berpikir kompleks yang mencangkup mengurai materi, mengkritik serta menciptakan solusi pada pemecahan masalah. Menanggapi hal yang sama, Thomas dan Thorne (2009) mendefinisikan HOTS sebagai kemampuan berpikir dengan membuat keterkaitan antar fakta terhadap sebuah permasalahan. Pemecahan masalah yang dilakukan tidak sekedar melalui proses mengingat atau menghafal saja, namun menuntut untuk membuat hubungan dan kesimpulan dari

permasalahan. Menyertai hal yang serupa Annuuru,dkk (2017:137) menjelaskan HOTS merupakan kemampuan menggabungkan fakta dan ide dalam proses menganalisis, mengevaluasi sampai pada tahap mencipta berupa memberikan penilaian terhadap suatu fakta yang dipelajari atau bisa mencipta dari sesuatu yang telah dipelajari. Proses menganalisis, mengevaluasi serta mencipta merupakan bagian dari taksonomi kognitif yang dibuat oleh Benjamin S. Bloom pada tahun 1956 (Saraswati and Agustika 2020).

B. Tingkatan Berpikir HOTS

Secara umum, tingkatan berpikir HOTS menurut Anderson dan Krathwohl (2017) adalah:

1. Mengingat

   Mengingat adalah aktivitas berpikir dengan menarik kembali pengetahuan yang relevan dalam memori jangka panjang seorang siswa. Untuk mengakses pembelajaran siswa dalam kategori proses kognitif yang paling sederhana ini, guru memberikan pertanyaan dalam kondisi yang sama persis dengan kondisi ketika siswa belajar materi yang diujikan. Di dalam mengingat ini, ada dua kategori proses

kognitif yakni mengenali dan mengingat kembali. Mengenali berarti mengambil pengetahuan yang dibutuhkan dari memori jangka panjang untuk membandingkannya dengan informasi yang baru saja diterima. Sedangkan mengingat kembali berarti mengambil pengetahuan yang dibutuhkan dari memori jangka panjang dan membawa kembali ke memori kerja untuk diproses.

2. Memahami

   Memahami berarti mengkonstruksi makna dari pesan-pesan pembelajaran, baik yang bersifat lisan, tulisan maupun grafis, yang disampaikan melalui pengajaran, buku atau layar komputer. Proses kognitif dalam kategori memahami meliputi menafsirkan, mencontohkan, mengklasifikasi, meringkas, menyimpulkan, membandingkan, dan menjelaskan

3. Menerapkan atau mengaplikasikan

   Menerapkan meliputi penggunaan prosedur atau cara kerja tertentu untuk mengerjakan suatu latihan atau menyelesaikan suatu masalah. Mengaplikasikan berkaitan erat dengan pengetahuan prosedural. Pengetahuan

prosedural adalah pengetahuan tentang cara melakukan sesuatu. Ada dua proses berpikirnya, yakni mengeksekusi dan mengimplementasikan. Dalam mengeksekusi, siswa secara rutin menerapkan prosedur ketika menghadapi tugas yang sudah biasa Sedangkan mengimplementasikan berlangsung saat siswa memilih dan menggunakan sebuah prosedur untuk menyelesaikan tugas yang tidak biasa.

4. Menganalisis

Menganalisis terdiri dari kemampuan atau keterampilan membedakan, mengorganisasi, dan menggabungkan. Menganalisis melibatkan proses memecah-mecah materi menjadi bagian-bagian kecil dan dapat menentukan bagaimana hubungan antar bagian dan antara setiap bagian dan struktur keseluruhannya. Kategori proses menganalisis ini meliputi membedakan, mengorganisasi dan mengatribusikan. Membedakan melibatkan proses memilah-milah bagianbagian yang penting dari sebuah struktur, kemudian mendiskriminasikan menjadi informasi yang relevan dan tidak relevan. Mengorganisasi melibatkan proses mengidentifikasi elemen-

elemen komunikasi atau situasi dan proses mengenali bagaimana elemen-elemen ini membentuk sebuah struktur yang koheren. Sedangkan mengatribusikan terjadi ketika siswa dapat menentukan sudut pandang, pendapat, nilai, atau tujuan di balik komunikasi.

5. Mengevaluasi

   Mengevaluasi merupakan kemampuan mengambil keputusan berdasarkan kriteria kriteria. Level ini terdiri dari keterampilan mengecek/memeriksa dan mengkritisi. Keterampilan memeriksa merupakan proses untuk menemukan inkonsistensi atau kesalahan dalam suatu proses atau produk. Misalnya, ketika siswa menguji apakah suatu kesimpulan sesuai dengan premis-premisnya atau tidak, apakah datanya mendukung atau tidak, atau apakah bahan pelajaran berisi bagian bagian yang saling bertentangan. Sedangkan mengkritisi adalah proses menilai suatu pendapat atau hasil berdasarkan kriteria tertentu yang tidak memihak, profesional dan universal. Dalam mengkritisi, siswa mencatat ciri-ciri positif dan negatif dari suatu produk dan membuat

keputusan setidaknya sebagian berdasarkan ciri-ciri tersebut. Mengkritisi merupakan inti dari apa yang disebut berpikir kritis.

6. Mencipta

   Pada level tertinggi ini, siswa mengorganisasi berbagai informasi menggunakan cara atau strategi yang baru atau berbeda dari biasanya. Keterampilan mencipta terdiri dari merumuskan, merencanakan, dan memproduksi. Merencanakan melibatkan proses merencanakan metode penyelesaian masalah yang sesuai dengan kriteria-kriteria masalahnya, yakni membuat rencana untuk menyelesaikan masalah. Merencanakan adalah mempraktikkan langkah-langkah untuk menciptakan solusi yang nyata bagi suatu masalah. Merumuskan melibatkan proses menggambarkan masalah dan membuat pilihan atau hipotesa yang memenuhi kriteria-kriteria tertentu. Sedangkan memproduksi melibatkan proses melaksanakan rencana untuk menyelesaikan masalah yang memenuhi spesifikasi tertentu (Kristiyono 2018)
   .

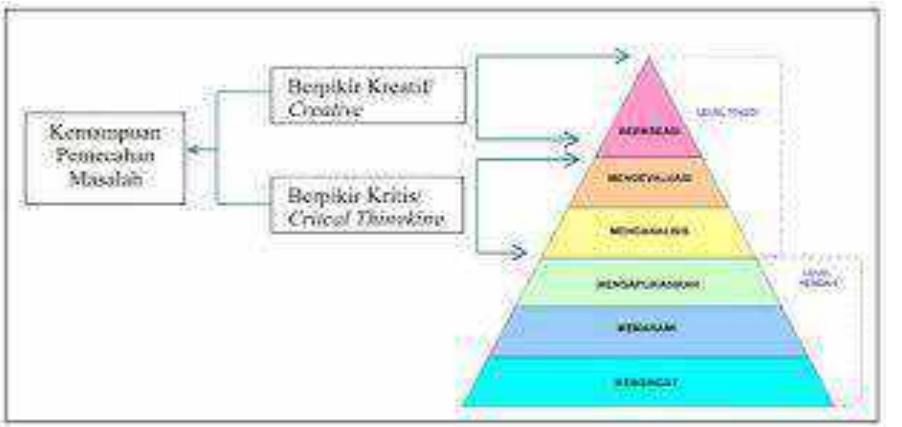
C. Indikator Analisis HOTS Siswa

Ada beberapa indikator yang harus ada dalam mendeskripsikan kemampuan HOTS, diantaranya (Hasyim and Andreina 2019) :

Kategori	Deskripsi
Menganalisis (*Analyze)*	● Menspesifikasikan aspek-aspek atau elemen. ● Kata kerja : membandingkan, memeriksa, mengkritik, dan menguji.
Mengevaluasi (*Evaluate)*	● Mengambil keputusan sendiri. ● Kata kerja : evaluasi, menilai, menyanggah, memutuskan, memilih, mendukung
Mencipta (*Create)*	● Mengkreasi ide/gagasan sendiri ● Kata kerja: mengkontruksi, desain, kreasi, mengembangkan, menulis, memformulasikan

Sumber: Anderson & Krathwohl (2001)

Kategori-kategori yang dipaparkan diatas merupakan bagian dari taksonomi kognitif yang dibuat oleh Benjamin S. Bloom pada tahun 1956 dan pada akhirnya disempurnakan kembali oleh Anderson dan Krathwohl (2001) menjadi C1-ingatan (remembering), C2-pemahaman (understanding), C3-menerapkan (applying), C4-analisis (analysing), C5-evaluasi (evaluating), dan C6-kreasi (creating). Menurut Tanujaya (2017:78) menjelaskan level satu sampai tiga merupakan kemampuan berpikir tingkat rendah atau LOTS (Lower Order Thinking Skill) dan level empat sampai enam merupakan HOTS (Higher Order Thinking Skill). Maka jika ditinjau dari ranah kognitif HOTS merupakan kemampuan menganalisis, mengevaluasi serta mencipta. Hal ini bisa dilihat dalam sebuah gambar dibawah ini :



Tabel

Taksonomi Kognitif HOTS

Dari gambar diatas bisa terlihat bahwa proses C4 dan C5 sebagai berpikir kritis, sedangkan C6 bagian dari kemampuan berpikir kreatif, kemampuan proses berpikir kritis dan kreatif digunakan untuk memecahkan masalah atau mencipta solusi untuk menetapkan keputusan (Saraswati and Agustika 2020).

D. Penerapan Pembelajaran HOTS di Sekolah

Dalam Dunia Pendidikan HOTS mampu diterapkan, sebab kemampuan berpikir tingkat tinggi siswa dapat dilatih dan ditingkatkan. Sehingga banyak negara yang mengunakan

HOTS sebagai bagian yang tak terpisahkan dari pembelajaran dikelas (Musrikah, 2018:341). Untuk mampu mengimplementasikan pembelajaran HOTS, maka semua stakeholder sekolah harus mendukung keberhasilan proses pembelajaran ini. Semua unsur-unsur di sekolah harus dipersiapkan dengan baik. Unsur-unsur itu meliputi siswa, orang tua siswa, fasilitas yang mendukung pembelajaran, maupun guru. Siswa sebagai subyek dan obyek pembelajaran harus mulai memahami tujuan pembelajaran yang diberikan guru. Harapannya dengan pembelajaran HOTS yang dibuat guru, maka siswa mampu mengaplikasikan kemampuan kritis dan analisisnya terhadap permasalahan di sekitarnya. Jadi pandangan siswa yang hanya menjadikan guru sebagai satu-satunya sumber belajar harus diubah. Siswa mulai berpikir menjadikan apa yang ada disekitarnya sebagai sumber belajar. Siswa secara aktif dibiasakan menerapkan konsep pembelajaran yang telah diterima di sekolah, untuk memecahkan masalah-masalah yang dihadapi saat ini (Kristiyono 2018).

Orang tua sebagai salah satu stakeholder, harus mendukung pula kemampuan berpikir HOTS. Bagian dari proses sosialisasi, sekolah mengadakan berbagai kegiatan bertema HOTS yang mengundang keterlibatan orang tua siswa. Mereka diberi informasi tentang kemampuan berpikir HOTS dan pentingnya bagi siswa saat ini. Kegiatan yang dilakukan sekolah, bisa berupa seminar, workshop, diskusi atau kegiatan-kegiatan lainnya. Koordinasi antara sekolah dengan orang tua siswa memang harus dilakukan secara terpadu, dan terus menerus. Dengan ini, tujuan pendidikan di sekolah yang mengembangkan kemampuan berpikir HOTS dapat tercapai.

Unsur lain yang tidak kalah pentingnya untuk mendukung keberhasilan penerapan kemampuan berpikir HOTS adalah fasilitas sekolah, terutama perpustakaan. Zaman sekarang perpustakaan memang banyak ditinggalkan siswa. Banyak orang tidak memanfaatkan perpustakaan dengan tepat, malas datang ke perpustakaan untuk membaca. Siswa maupun guru lebih suka mencari berbagai sumber

informasi dari internet, sehingga keinginan dan kemauan untuk membaca di perpustakaan rendah. Dalam kaitan dengan upaya mendukung keberhasilan pembelajaran HOTS, perpustakaan wajib menyediakan berbagai buku yang bertema HOTS yang bisa dipakai oleh siswa maupun guru. Dengan membaca buku tentang HOTS, siswa dan guru makin memahami tentang HOTS. Ketersediaan buku ini, ditindaklanjuti dengan berbagai program pembelajaran yang menggiatkan siswa untuk membaca, sebagai bagian mendukung program literasi sekolah.

Unsur terakhir yang paling penting dan merupakan ujung tombak perubahan pembelajaran HOTS adalah guru. Dalam kaitan pembelajaran HOTS di sekolah, guru harus mau mengubah mindset pembelajaran yang diterapkannya di sekolah. Pembelajaran yang dahulu didominasi sistem monolog dan ceramah, harus diubah dengan pola baru yang menggiatkan potensi dan kemampuan siswa secara optimal dengan menerapkan kemampuan berpikir HOTS.

E. Design Tahapan Pembelajaran HOTS

Guru harus mendesain pembelajaran dan penilaian HOTS ini dengan matang, dari tahapan persiapan, pelaksanaan, dan evaluasi. Tahapan persiapan, dimulai dengan pembuatan RPP yang dirancang, dilaksanakan, dan dievaluasi secara terpadu. Pembuatan RPP dapat mengintegrasikan prinsip-prinsip pembuatan RPP yang ditetapkan dalam Permendikbud Nomor 22 Tahun 2013 dengan konsep literasi, pendidikan karakter, HOTS, dan tuntutan pembelajaran abad XXI. Integrasi dapat dituangkan pada penulisan indikator, tujuan, kegiatan pendahuluan, kegiatan inti, kegiatan penutup, dan penilaian.

Dalam tahapan pelaksanaan pembelajaran HOTS, guru menerapkan model pembelajaran yang membiasakan siswa berpikir tingkat tinggi. Istiqomah (2018) menyebutkan ada beberapa model pembelajaran berpikir tingkat tinggi (HOTS), yakni discovery (penemuan terbimbing) dan inquiry (inkuiri, penyelidikan) (Kristiyono 2018). Pembelajaran discovery adalah proses pembelajaran yang mendorong siswa mengasimilasikan suatu konsep atau suatu prinsip dengan bimbingan dari guru.

Pembelajaran discovery menempatkan guru sebagai fasilitator, guru membimbing siswa ketika diperlukan. Dalam model ini siswa didorong untuk berpikir sendiri sehingga dapat menemukan prinsip umum berdasarkan bahan atau data yang telah disediakan guru. Sampai seberapa jauh siswa dibimbing, tergantung kemampuannya dan materi yang sedang dipelajari.

Tahapan evaluasi dalam pembelajaran HOTS , dilakukan dengan membuat penilaian kepada siswa yang mengukur kemampuan berpikir tingkat tinggi yang dimilikinya. Pengukuran dilakukan terhadap kemampuan berpikir yang tidak sekedar mengingat (recall), menyatakan kembali (restate), atau merujuk tanpa melakukan pengolahan (recite), melainkan mengukur dimensi metakognitif yang menggambarkan kemampuan menghubungkan beberapa konsep yang berbeda, menginterpretasikan, memecahkan masalah, memilih strategi pemecahan masalah, menemukan metode baru, berargumen dan mengambil keputusan yang tepat.

BAB III
PENUTUP

A. Kesimpulan

Model pembelajaran adalah suatu perencanaan atau suatu pola yang digunakan sebagai pedoman dalam merencanakan pembelajaran di kelas atau pembelajaran dalam tutorial. Fungsi model pembelajaran adalah sebagai pedoman bagi perancang pengajaran dan para guru dalam melaksanakan pembelajaran. Pemilihan model pembelajaran sangat dipengaruhi oleh sifat dari materi yang akan diajarkan, tujuan yang akan dicapai dalam pembelajaran tersebut, serta tingkat kemampuan peserta didik. Setiap model memerlukan pengelolaan dan lingkungan belajar yang berbeda. Setiap pendekatan memberikan peran yang berbeda kepada siswa, pada ruang fisik, dan pada sistem sosial kelas.

Penggunaan media dalam pengajaran di kelas merupakan sebuah kebutuhan yang tidak dapat diabaikan. Hal ini dapat dipahami mengingat proses belajar yang dialami siswa tertumpu pada berbagai kegiatan menambah ilmu dan wawasan untuk bekal hidup di masa sekarang dan masa akan datang. Salah

satu upaya yang harus ditempuh adalah bagaimana menciptakan situasi belajar yang memungkinkan terjadinya proses pengalaman belajar pada diri siswa dengan menggerakkan segala sumber belajar dan cara belajar yang efektif dan efisien. Dalam hal ini, media pengajaran merupakan salah satu pendukung yang efektif dalam membantu terjadinya proses belajar.

Kemampuan berpikir tingkat tinggi (HOTS) merupakan keterampilan berpikir yang mampu membentuk anak tidak hanya sekedar meretensi pengetahuan, tetapi sudah pada level mentransfer. Anak bisa menerapkan dan mempraktekkan pengetahuannya untuk memecahkan masalah yang dihadapinya saat ini, khususnya tantangan modernisasi dan globalisasi. Penerapan HOTS memerlukan keterlibatan semua pihak di lingkungan pendidikan, dan tidak hanya pada tataran konsep, tetapi juga berupa praktek nyata. Dukungan terhadap penerapan pembelajaran HOTS dapat dilakukan dengan menyediakan fasilitas yang mendukung. Guru sebagai garda terdepan harus mampu menjadi pendobrak perubahan, minimal dalam lingkup yang bisa ditangani sendiri, seperti dalam perencanaan, pelaksanaan, dan evaluasi pembelajaran.

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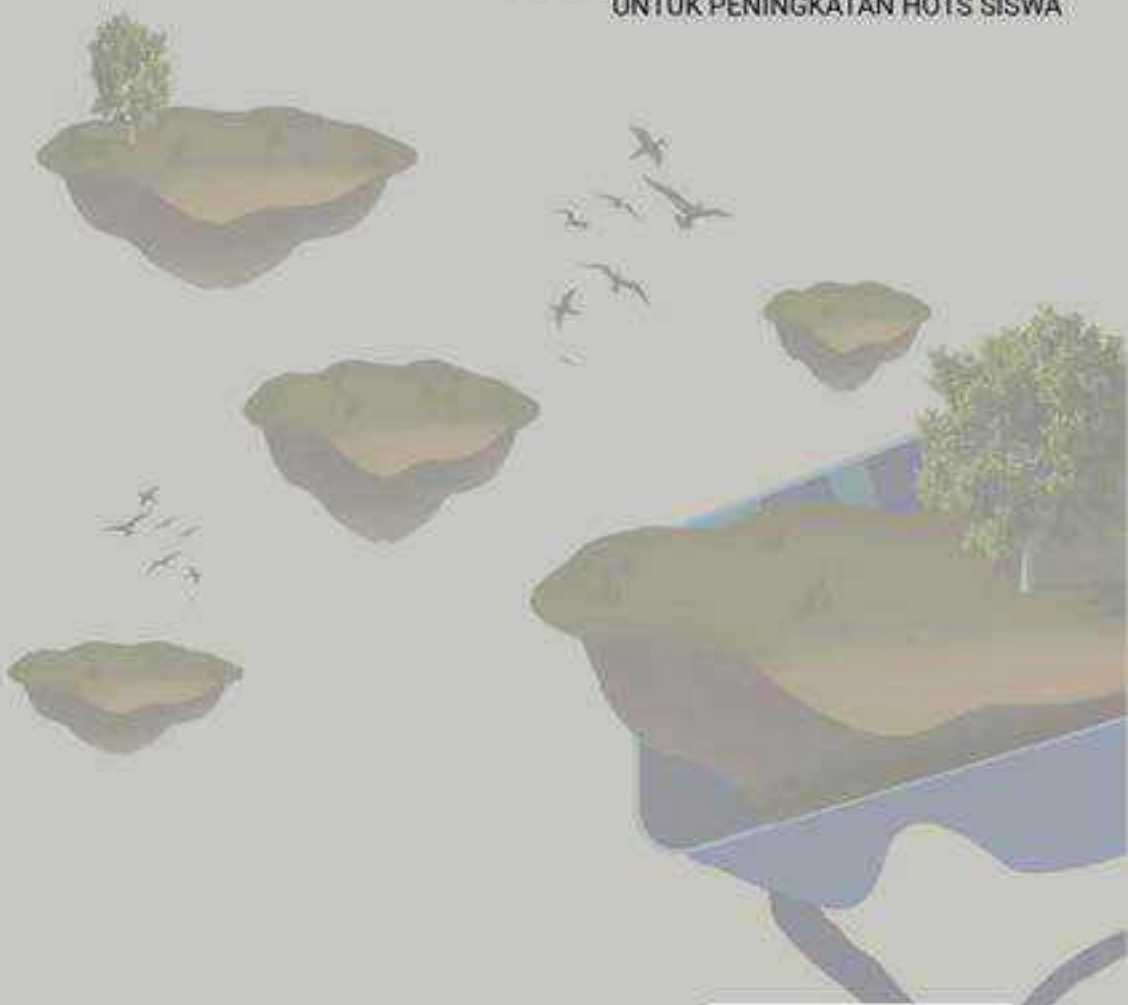
MODEL PEMBELAJARAN BERBASIS *PROBLEM BASED LEARNING* BERBANTUAN *VIRTUAL REALITY*

UNTUK PENINGKATAN HOTS SISWA



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JENIS KARYA KARYA TULIS SUBJENIS BUKU, JUDUL:
Model Pembelajaran Berbasis *Problem Based Learning* Berbantuan *Virtual Reality* untuk Peningkatan HOTS Siswa

URAIAN SINGKAT:
Setiap model memerlukan pengelolaan dan lingkungan belajar yang berbeda. Setiap pendekatan memberikan peran yang berbeda kepada siswa, pada ruang fisik, dan pada sistem sosial kelas. Penggunaan media dalam pengajaran di kelas merupakan sebuah kebutuhan yang tidak dapat diabaikan. Hal ini dapat dipahami mengingat proses belajar yang dialami siswa tertumpu pada berbagai kegiatan menambah ilmu dan wawasan untuk bekal hidup di masa sekarang dan masa akan datang. Salah satu upaya yang harus ditempuh adalah bagaimana menciptakan situasi belajar yang memungkinkan terjadinya proses pengalaman belajar pada diri siswa dengan menggerakkan segala sumber belajar dan cara belajar yang efektif dan efisien. Dalam hal ini, media pengajaran merupakan salah satu pendukung yang efektif dalam membantu terjadinya proses belajar. Kemampuan berpikir tingkat tinggi (HOTS) merupakan keterampilan berpikir yang mampu membentuk anak tidak hanya sekedar meretensi pengetahuan, tetapi sudah pada level mentransfer. Anak bisa menerapkan dan mempraktekkan pengetahuannya untuk memecahkan masalah yang dihadapinya saat ini, khususnya tantangan modernisasi dan globalisasi. Penerapan HOTS memerlukan keterlibatan semua pihak di lingkungan pendidikan, dan tidak hanya pada tataran konsep, tetapi juga berupa prakteknya.

TANGGAL PUBLIKASI:
Yogyakarta, 7 Desember 2023

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1.	Nama	:	Prof. Dr. Ir. Dwi Sulisworo, MT
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2.	Nama	:	Vera Yuli Erviana
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4.	Nama	:	Eva Rismawati Nur Afina
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“Penguatan Keterampilan Berpikir Kritis dengan Strategi Pembelajaran Berbasis Hipotetikal-Deduktif Berbantuan Virtual Reality Tema Ekosistem (Zoo-VR)”

DWI SULISWORO
NIDN :0514056701

VERA YULI ERVIANA
NIDN : 0525079001

BAMBANG ROBI’IN
NIDN : 0020077901

Lokasi Penelitian

1. **SD Muhammadiyah Klepu**
2. **SD Muhammadiyah Mertosanan**
3. **SDN Balirejo**
4. **SD Muhammadiyah Ngadiwinata**
5. **Desa Wisata Tinalah**
6. **Kampung Wisata Purbayan, Kota Gede**

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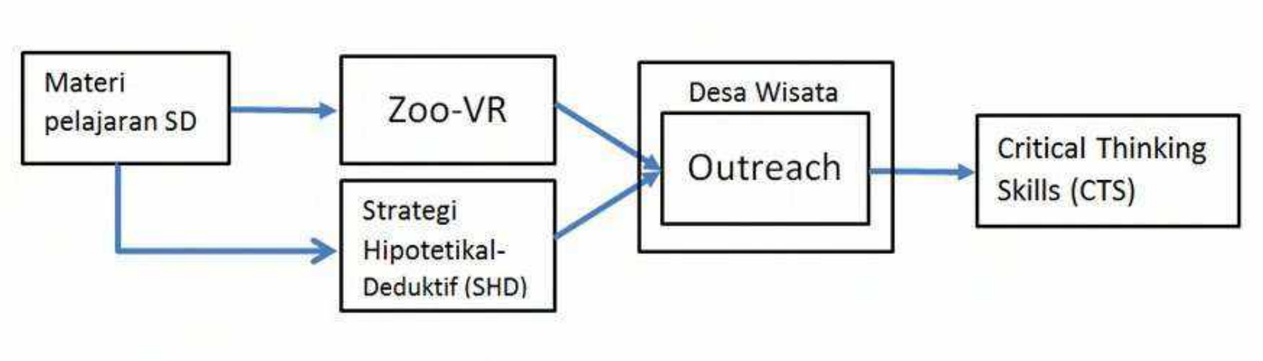
2023

Latar Belakang



Gambar 1. Model Konseptual

Transformasi digital telah mengubah banyak kegiatan dan Kajian kompetensi di era digital menempatkan keterampilan berpikir kritis (CTS atau critical thinking skills) sebagai hal yang penting dalam kehidupan masyarakat; termasuk dalam pendidikan. Dalam proses pengembangan lingkungan belajar tersebut, peneliti bersama tim telah mengembangkan teknologi yang relevan dengan era digital (IoT, AR, VR) diintegrasikan dalam pembelajaran yang terdapat pada roadmap penelitian di Metode. Untuk melengkapi pencapaian target penelitian tahun 2025 terkait penyediaan outreach program di Desa Wisata berbasis teknologi.

Tujuan Penelitian

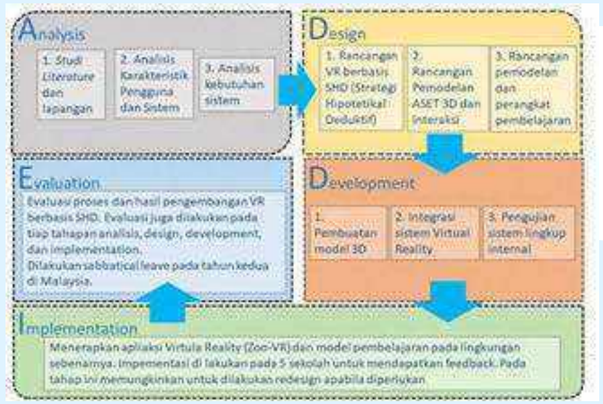
Tujuan khusus pada penelitian untuk mengembangkan media *virtual reality* berbasis SHD yang layak, praktis, dan efektif untuk mendorong CTS.

Kebaharuan Penelitian

Kebaharuan penelitian yaitu dengan menggunakan metode dan sistem simulasi kehidupan binatang berbasis realitas virtual atau *Zoo-VR.*

Metode Penelitian

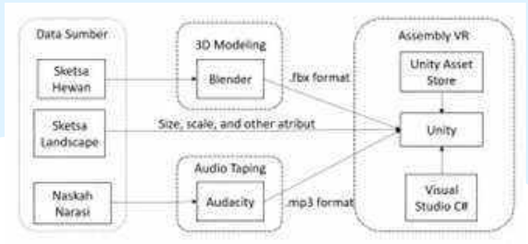
Penelitian ini gabungan antara penelitian kualitatif dan kuantitatif. Penelitian ini menggunakan model ADDIE (analyze, design, develop, implement, dan evaluate).



Hasil Penelitian

1. Pengembangan Aplikasi VR-Zoo

Tahap pertama adalah menentukan data sumber, kemudian tahap kedua pembuatan asset yang terdiri dari modeling dan audio taping, kemudian tahap ketiga yaitu assembly VR application. Tahapan pengembangan aplikasi VR-Zoo ini.

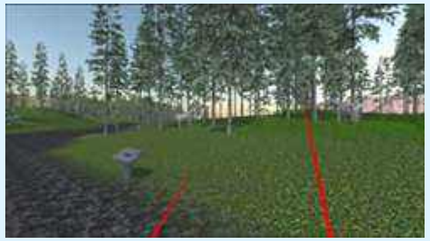


2.. Desain Lanscape Area Kebun Binatang Virtual (VR-Zoo)

Kebun binatang virtual dirancang dengan ukuran dan skala yang dapat menampung 30 jenis hewan dengan setiap jenis hewan menempati suatu lokasi yang memiliki karakteristik habitat dari hewan tersebut.

3. Pengembangan Aplikasi VR-Zoo

Aplikasi virtual reality kebun binatang ini di buat dengan mempertimbangkan ukuran, skala, dan atribut-atribut lain seperti kontur permukaan dan krakteristik lingkungan.



4. Keterampilan Papan Nama dan Deskripsi Hewan Kelinci

Pada papan nama ini juga terdapat sebuah kotak dialog (pop-up) untuk menampilkan deskripsi dari setiap hewan yang dilengkapi dengan suara narasi penjelasan.

5. Sesi Pengantar dengan Teknologi VR

Setiap siswa diizinkan untuk menggunakan headset VR Meta Quest 2 untuk menjelajahi dan terlibat dengan habitat hewan virtual. kegiatan praktik menggunakan VR dalam pembelajaran. Kurikulum berbasis VR mencakup berbagai topik yang berkaitan dengan hewan, seperti habitat, gerakan, karakteristik fisik, suara, dan penjelasan teks yang menyertainya.

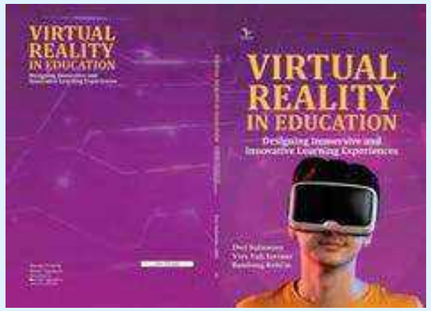
6. Praktik Menggunakan VR

Siswa menggambarkan karakteristik hewan setelah terlibat dalam pengamatan berbasis VR. Teknologi VR memungkinkan siswa untuk membenamkan diri di habitat hewan virtual, sehingga memudahkan mereka untuk mengamati dan memahami karakteristik fisik dan perilaku hewan.

Luaran Wajib

1. Artikel diterima (Accepted) pada Jurnal Internasional Bereputasi (Q2).

Luaran Tambahan



1. Bookchapter dengan judul "*Virtual Reality In Education: Designing Immersive And Innovative Learning Experiences*".

2. Publikasi di prosiding Seminar Internasional dengan judul "*Enhancing Elementary School Students' Environment Awareness Through Virtual Reality Based Immersive Learning Experiences*".

3. HKI *Virtual Reality: A Tool for Immersive Science Experiences* .

4. Paten Sederhana dengan Judul : Metode dan Sistem Simulasi Kehidupan Binatang Berbasis Realitas Virtual.

Kesimpulan

grasi teknologi dan pendidikan serta pembelajaran difasilitasi dalam kelompok riset peneliti dengan pengembangan Desa Wisata Pendidikan (Eduwisata) sebagai outreach berbasis teknologi era digital. Pengintegrasian ini telah dirintis peneliti bersama tim dengan mengembangkan berbagai teknologi (IoT, AR, VR) yang diintegrasikan dalam pembelajaran baik di kelas maupun luar kelas (outreach program). Hanya saja dalam mencapai target pengembangan Penyediaan Desa Wisata berbasis teknologi masih terkendala pada aspek kajian VR sebagai outreach program. VR yang direncanakan ini terkait dengan isu global ecosystem yang menjadi fokus pengembangan mitra Desa Wisata. Pengembangan model pembelajaran melibatkan berbagai kehidupan sesuai habitat hewan dan perilakunya sebagai materi dalam ekosistem ini sangat penting. Namun demikian, banyak keterbatasan untuk dapat menghadirkan model tersebut. Keterbatasan ini menjadi peluang untuk memanfaatkan VR yang berorientasi pada CTS.

Saran

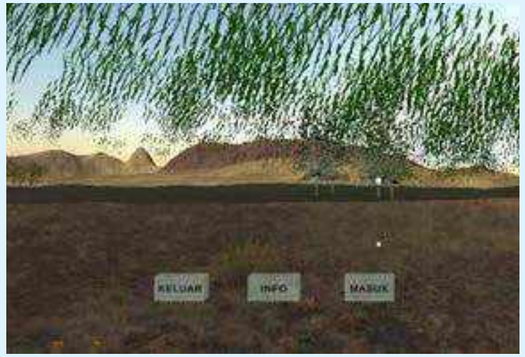
Permasalahan dalam keberlanjutan penelitian saat ini adalah masih belum dikembangkan VR tentang global ecosystem berbasis SHD untuk mendorong CTS. sehingga solusi yaitu dapat mengembangkan VR tentang global ecosystem berbasis SHD untuk mendorong CTS.

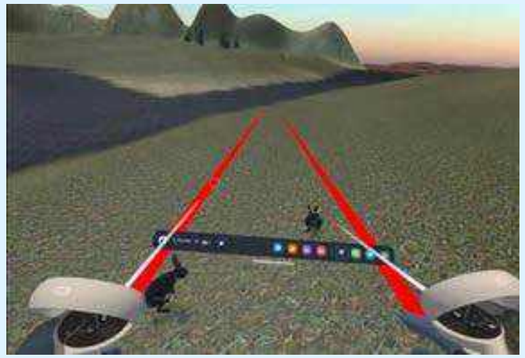
Rekomendasi

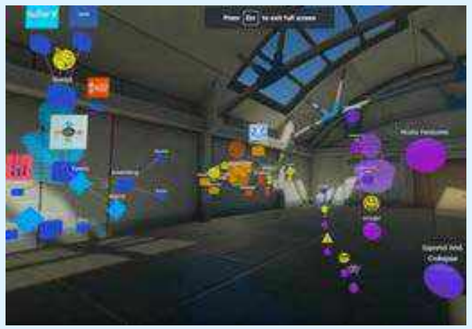
Berkaitan dengan jumlah hewan yang terdapat di dalam VR sehingga menjadi media menjadi lebih menarik dan meningkatkan informasi lebih lanjut berkaitan dengan habitat hewan serta perilakunya sebagai mahluk hidup.

Dokumentasi Kegiatan

Foto hasil-hasil penelitian







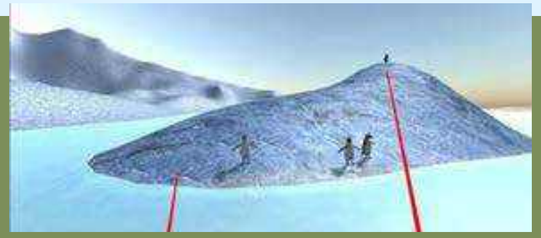


Foto-foto aktivitas penelitian

PERGURUAN TINGGI MUHAMMADIYAH
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UAD Kampus 2 Unit 8, Jl. Pramuka no. 5F, Pandeyan, Umbulharjo Yogyakarta 55161, email : lppm@uad.ac.id

SURAT PERNYATAAN TANGGUNG JAWAB BELANJA

Yang bertanda tangan di bawah ini :

Nama : Dr Ir DWI SULISWORO S.T, M.T
Alamat : Jl. Sugeng Jeroni 36

berdasarkan Surat Keputusan Nomor 0217/E5/PG.02.00/2023 dan Perjanjian / Kontrak Nomor 075/E5/PG.02.00.PL/2023; 0254.8/LL3-INT/AL.04/2023; 002/PDUPT-LPPMUAD/IV/2023 mendapatkan Anggaran Penelitian Penguatan Keterampilan Berpikir Kritis dengan Strategi Pembelajaran Berbasis Hipotetikal-Deduktif Berbantuan Virtual Reality Tema Ekosistem (Zoo-VR) Sebesar 264.760.000

Dengan ini menyatakan bahwa :

1. Biaya kegiatan Penelitian di bawah ini meliputi :

No	Uraian	Jumlah
01	**Bahan** Seminar Kit, Okulus, Sketsa Hewan	65.730.000
02	**Pengumpulan Data** Honor pembantu lapangan, Honor pembantu peneliti, Uang harian rapat dalam kantor, Uang harian rapat luar kantor, Uang harian pengumpulan data, FGD edutwisata berbasis VR, Honor sekretariat administrasi peneliti saat pengumpulan data, Transport FGD, Konsumsi kegiatan, Honor petugas survei, Pajak	49.030.000
03	**Analisis Data(Termasuk Sewa Peralatan** Uang harian menganalisis kebutuhan pengembangan VR, Honorarium FGD, Biaya analisis sampel, Konsumsi, Honorarium pengolah data, Transport kegiatan, Honor sekretariat peneliti saat menganalisis data, Sewa komputer multimedia, Sewa Ruangan, Honorarium narasumber FGD, Pajak	62.300.000
04	**Pelaporan, Luaran Wajib dan Luaran Tambahan** Uang harian rapat penyusunan laporan kemajuan dan membahas luaran, Biaya publikasi seminar internasional: EDULEARN23 Proceedings, Honor sekretariat peneliti saat pengumpulan luaran, Buku Virtual Reality In Education: Designing Immersive and Innovative Learning Experiences	87.700.000
05	**Lain-lain** -	0
	Jumlah	264.760.000

2. Jumlah uang tersebut pada angka 1. benar-benar dikeluarkan untuk pelaksanaan kegiatan Penelitian dimaksud.

Demikian surat pernyataan ini dibuat dengan sebenarnya.

Yogyakarta, 05-12-2023
Ketua

(Dr Ir DWI SULISWORO S.T, M.T)
NIP/NIK 347108140567000S