

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE
BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR
KRITIS DAN KETERAMPILAN PROSES SAINS SISWA

TESIS

diajukan untuk memenuhi syarat memperoleh gelar Magister Pendidikan Biologi



Oleh

NADIA
NIM 1906513

PROGRAM STUDI
PENDIDIKAN BIOLOGI
SEKOLAH PASCASARJANA
UNIVERSITAS PENDIDIKAN INDONESIA
2021

**PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE
BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN
BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA**

Oleh:

Nadia

S.Pd Universitas Riau, 2019

Sebuah tesis yang diajukan untuk memenuhi salah satu syarat untuk memperoleh
gelar Magister Pendidikan Biologi

© Nadia 2021

Universitas Pendidikan Indonesia

2021

Hak Cipta dilindungi undang-undang

Tesis ini tidak boleh diperbanyak seluruhnya atau sebagian, dengan dicetak ulang,
difotokopi, atau cara lainnya tanpa izin dari penulis.

Nadia, 2021

**PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK
MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA**

Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

NADIA

**PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE
BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN
BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA**

disetujui dan disahkan oleh pembimbing:

Pembimbing I



Dr. Bambang Supriatno, M.Si
NIP. 196305211988031002

Pembimbing II:



Dr. Kusnadi, M.Si
NIP. 196805091994031001

Mengetahui,
Ketua Departemen Pendidikan Biologi
Sekolah Pascasarjana Universitas Pendidikan Indonesia



Dr. Bambang Supriatno, M.Si
NIP. 196305211988031002

PERNYATAAN ORISINALITAS

Dengan ini saya menyatakan bahwa tesis dengan judul "Pengembangan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri Untuk Meningkatkan Kemampuan Berpikir Kritis dan Keterampilan Proses Sains Siswa" ini beserta seluruh isinya adalah benar-benar karya saya sendiri. Saya tidak melakukan penjiplakan atau pengutipan dengan cara-cara yang tidak sesuai dengan etika ilmu yang berlaku dalam masyarakat keilmuan. Atas pernyataan ini, saya siap menanggung risiko/sanksi apabila di kemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

Bandung, Agustus 2021



Nadia

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

**PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM
KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN
KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN
PROSES SAINS SISWA**

Nadia

Email: Nadia06@upi.edu

ABSTRAK

Fasilitas laboratorium yang tidak memadai, waktu yang terbatas dan pandemi Covid-19 menjadi kendala dalam melaksanakan kegiatan praktikum. Untuk mengatasi masalah tersebut, maka kegiatan praktikum dilakukan secara virtual. Penelitian ini bertujuan untuk mengembangkan laboratorium virtual enzim katalase berbasis inkuiri untuk meningkatkan kemampuan berpikir kritis dan keterampilan proses sains siswa. Penelitian ini menggunakan desain instruksional pengembangan model ADDIE (*Analyze, Design, Develop, Implement and Evaluation*). Sampel penelitiannya adalah 80 siswa kelas XII di salah satu SMA yang ada di Riau. Instrumen penelitian yang digunakan berupa lembar validasi, angket uji keterbacaan laboratorium virtual, soal tes kemampuan berpikir kritis dan keterampilan proses sains dan angket tanggapan guru. Hasil penelitian menunjukkan tingkat kelayakan laboratorium virtual yang dikembangkan berada dalam kategori sangat layak yaitu 94.77% pada aspek media dan kategori layak yaitu 84.52% pada aspek materi. Hasil uji keterbacaan laboratorium virtual menunjukkan nilai rata-rata 83.25% dengan kategori sangat baik. Nilai rata-rata angket tanggapan guru sebesar 82.63% dengan kategori sangat baik. Rata-rata N-Gain kemampuan berpikir kritis siswa sebesar 0.57 (kategori sedang) dan rata-rata N-Gain keterampilan proses sains siswa sebesar 0.77 (kategori tinggi). Jadi dapat disimpulkan bahwa laboratorium virtual enzim katalase berbasis inkuiri yang dikembangkan layak digunakan dalam pembelajaran Biologi dan dapat meningkatkan kemampuan berpikir kritis dan keterampilan proses sains siswa SMA.

Kata kunci: Laboratorium Virtual, Kemampuan Berpikir Kritis, Keterampilan Proses Sains

**THE DEVELOPMENT OF AN INQUIRY-BASED CATALASE
ENZYME VIRTUAL LABORATORY FOR IMPROVING
STUDENTS' CRITICAL THINKING AND SCIENCE PROCESS
SKILLS**

Nadia

Email: Nadia06@upi.edu

ABSTRACT

The inadequate laboratory facilities, limited time, and the Covid-19 pandemic have become obstacles in carrying out practicum activities. To overcome this problem, practicum activities are carried out virtually. The inadequate laboratory facilities, limited time, and the Covid-19 pandemic have become obstacles in carrying out practicum activities. To overcome this problem, practicum activities are carried out virtually. This research aimed to develop an inquiry-based catalase enzyme virtual laboratory for improving student's critical thinking and science process skills. This research used the development of an instructional design of the ADDIE model (Analyze, Design, Develop, Implement, and Evaluation). The research sample was 80 students at one of the senior high school in Riau. The research instruments used were validation sheets, virtual laboratory readability test, critical thinking questions test, and science process skills and teacher response questionnaire. The results showed that the feasibility level of the virtual laboratory developed was in the very feasible category namely 94.77% in the media aspect and feasible category namely 84.52% in the material aspect. The virtual laboratory readability test result showed an average value of 83.25% that is in a very good category. The average value of the teacher's response questionnaire is 82.63% that is in a very good category. The N-Gain average of critical thinking skills was 0.57 (medium category) and the N-Gain average of science process skill was 0.77 (high category). So it can be concluded that the Inquiry-Based Catalase Enzyme Virtual Laboratory that was developed is applicable for use in Biology learning and can improve the critical thinking and science process skills students in senior high school.

Keywords: Virtual Laboratory, Critical Thinking Ability, Science Process Skills

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

KATA PENGANTAR

Puji dan syukur penulis ucapkan kehadirat Allah SWT, Tuhan yang Maha Esa yang telah memberikan rahmat dan hidayah-Nya sehingga penulis dapat menyelesaikan Tugas Akhir yang berjudul “Pengembangan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri Untuk Meningkatkan Kemampuan Berpikir Kritis dan Keterampilan Proses Sains Siswa” guna memenuhi persyaratan dalam memperoleh gelar Magister Pendidikan Biologi pada Program Studi Pendidikan Biologi, Sekolah Pascasarjana, Universitas Pendidikan Indonesia.

Penulis mengucapkan terimakasih kepada semua pihak yang membantu dalam penulisan tesis ini, terutama kepada:

1. Bapak Dr. Bambang Supriatno, M.Si selaku Kepala Departemen Pendidikan Biologi dan dosen pembimbing I yang telah memberikan bimbingan, arahan, saran dan dukungan.
2. Bapak Dr. Kusnadi, M.Si selaku dosen pembimbing II yang telah memberikan bimbingan, arahan, saran dan dukungan.
3. Bapak dan Ibu Dosen Program Studi Pendidikan Biologi FPMIPA Universitas Pendidikan Indonesia yang telah membekali ilmu pengetahuan kepada penulis selama mengikuti perkuliahan.
4. Bapak Prof. Dr. H. Ari Widodo, M.Ed dan Bapak Drs. Suhara, M.Pd yang telah bersedia melakukan *judgment* terhadap instrumen penelitian yang digunakan dalam tesis ini.
5. Bapak Tri Suwandi, S.Pd., M.Sc dan Ibu Persahini Sidik, M.Pd yang telah bersedia melakukan validasi terhadap laboratorium virtual enzim katalase yang dikembangkan.
6. Ibu Dr. Yanti Hamdiyati M.Si dan Bapak Dr.H. Riandi, M.Si selaku penguji yang telah memberikan saran dan masukan untuk kesempurnaan tesis ini.
7. Ibu Hera Asriana, S.Pd selaku Guru Biologi di Madrasah Aliyah Nurul Islam yang telah memberikan izin untuk melakukan uji keterbacaan laboratorium virtual enzim katalase kepada siswanya.
8. Ibu Yurnalia, S.Pd selaku Guru Biologi di SMA Negeri 1 Kampar Kiri yang telah memberikan izin untuk melakukan penelitian kepada siswanya.
9. Rekan-rekan mahasiswa/I Pascasarjana Program Studi Pendidikan Biologi khususnya angkatan 2019 yang selalu memberikan semangat dan bantuan kepada penulis.

Penulis menyadari bahwa penulisan tesis ini masih jauh dari kesempurnaan, Oleh karena itu penulis sangat mengharapkan kritik dan saran yang membangun untuk kesempurnaan tesis ini. Semoga tesis ini bermanfaat bagi kita semua.

Bandung, Agustus 2021

Penulis

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA

Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

DAFTAR ISI

	Halaman
HALAMAN PENGESAHAN.....	i
PERNYATAAN ORISINALITAS.....	ii
ABSTRAK.....	iii
KATA PENGANTAR.....	v
DAFTAR ISI.....	vi
DAFTAR TABEL.....	viii
DAFTAR GAMBAR.....	x
DAFTAR LAMPIRAN.....	xi
BAB I PENDAHULUAN.....	1
1.1 Latar Belakang Penelitian.....	1
1.2 Rumusan Masalah Penelitian.....	8
1.3 Pertayaan Penelitian.....	9
1.4 Batasan Penelitian.....	9
1.5 Tujuan Penelitian.....	10
1.6 Manfaat/Signifikansi Penelitian.....	11
1.7 Struktur Organisasi Tesis.....	12
BAB II KAJIAN PUSTAKA.....	14
2.1 Praktikum dalam Pembelajaran Biologi.....	14
2.2 Laboratorium Virtual.....	21
2.3 Pembelajaran Berbasis Inkuiri.....	27
2.4 Virtual Laboratorium berbasis Inkuiri pada Pembelajaran Biologi.....	30
2.5 Kemampuan Berpikir Kritis.....	33
2.6 Keterampilan Proses Sains.....	40
2.7 Tinjauan Tentang Enzim Katalase dalam Pembelajaran Biologi.....	52
BAB II METODOLOGI PENELITIAN.....	58
3.1 Desain Penelitian.....	58
3.2 Partisipan dan Tempat Penelitian.....	59

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA

Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

3.3 Defenisi Operasional.....	60
3.4 Instrumen penelitian.....	61
3.5 Prosedur Penelitian.....	67
3.6 Analisis Data Penelitian.....	70
BAB IV HASIL DAN PEMBAHASAN.....	76
4.1 Tahapan Pengembangan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri	76
4.2 Karakteristik Laboratorium Virtual Enzim Katalase Berbasis Inkuiri	81
4.3 Hasil Validasi Laboratorium Virtual Enzim Katalase Berbasis Inkuiri	92
4.4 Hasil Uji Keterbacaan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri	96
4.5 Kemampuan Berpikir Kritis Siswa Melalui Pembelajaran Menggunakan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri	99
4.6 Keterampilan Proses Sains Siswa Melalui Pembelajaran Menggunakan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri.....	107
4.7 Tanggapan Guru Terhadap Penggunaan Laboratorium Virtual Enzim Katalase Berbasis Inkuiri dalam Pembelajaran Biologi.....	117
4.8 Evaluasi terhadap Laboratorium Virtual Enzim Katalase Berbasis Inkuiri	121
BAB V KESIMPULAN, IMPLIKASI, DAN REKOMENDASI	123
5.1 Kesimpulan.....	123
5.2 Implikasi.....	124
5.3 Rekomendasi.....	125
DAFTAR PUSTAKA.....	127
LAMPIRAN.....	145

DAFTAR TABEL

	Halaman
Tabel 2.1	Perbandingan Kelebihan dan Kekurangan Laboratorium Nyata dan Laboratorium Virtual..... 25
Tabel 2.2	Indikator Berpikir Kritis Ennis (2015)..... 35
Tabel 2.3	Indikator Berpikir Kritis Norris&Ennis..... 37
Tabel 2.4	Karakteristik Setiap Indikator Keterampilan Proses Sains..... 47
Tabel 3.1	Kisi-kisi Instrumen Validasi Media..... 62
Tabel 3.2	Kisi-kisi Instrumen Validasi Materi..... 62
Tabel 3.3	Kisi-kisi Angket Uji Keterbacaan..... 63
Tabel 3.4	Kisi-kisi Angket Tanggapan Guru..... 64
Tabel 3.5	Kisi-kisi Soal Tes Kemampuan Berpikir Kritis..... 65
Tabel 3.6	Kisi-kisi Soal Tes Keterampilan Proses Sains..... 66
Tabel 3.7	Teknik Pengumpulan Data..... 66
Tabel 3.8	Kriteria Kelayakan Virtual Laboratorium..... 70
Tabel 3.9	Kriteria Validitas..... 71
Tabel 3.10	Klasifikasi Tingkat Kesukaran..... 71
Tabel 3.11	Interpretasi Daya Pembeda..... 72
Tabel 3.12	Hasil Analisis Butir Soal Kemampuan Berpikir Kritis..... 72
Tabel 3.13	Hasil Analisis Butir Soal Keterampilan Proses Sains..... 73
Tabel 3.14	Kategori N-Gain..... 74
Tabel 3.15	Kategori Bobot Nilai dengan Skala Likert..... 75
Tabel 3.16	Kategori Persentase Hasil Angket..... 75
Tabel 4.1	Hasil Analisis Data Validasi Ahli Media..... 93
Tabel 4.2	Hasil Analisis Data Validasi Ahli Materi..... 95
Tabel 4.3	Hasil Analisis Data Uji Keterbacaan Laboratorium Virtual Enzim Katalase..... 97
Tabel 4.4	Tingkat Kemampuan Berpikir Kritis Siswa..... 100
Tabel 4.5	Rata-rata Nilai Pretest, Posttest dan N-Gain Kemampuan Berpikir Kritis Siswa..... 104
Tabel 4.6	Tingkat Keterampilan Proses Sains Siswa..... 107

Tabel 4.7	Rata-rata Nilai Pretest, Posttest dan N-Gain Keterampilan Proses Sains Siswa.....	113
Tabel 4.8	Rekapitulasi Tanggapan Guru terhadap Pembelajaran dengan Laboratorium Virtual Enzim Katalase.....	117

DAFTAR GAMBAR

	Halaman
Gambar 2.1 Model yang Menggambarkan Hubungan Antara Keterampilan Proses Sains dengan Metode Ilmiah.....	49
Gambar 3.1 Desain Implementasi Virtual Laboratorium Enzim Katalase Berbasis Inkuiri.....	59
Gambar 3.2 Prosedur Penelitian.....	69
Gambar 4.1 <i>Flowchart</i> Laboratorium Virtual Enzim Katalase.....	79
Gambar 4.2 Tampilan Bagian Pembuka.....	85
Gambar 4.3 Tampilan Menu Utama.....	86
Gambar 4.4 Tampilan Menu Petunjuk Penggunaan.....	87
Gambar 4.5 Tampilan Menu Kompetensi Dasar dan Tujuan Pembelajaran.....	87
Gambar 4.6 Tampilan Menu Materi.....	88
Gambar 4.7 Tampilan Awal Menu Praktikum.....	88
Gambar 4.8 Tampilan Pemilihan Bahan pada Menu Praktikum.....	89
Gambar 4.9 Tampilan Laboratorium pada Menu Praktikum.....	90
Gambar 4.10 Tampilan Tabel Pengamatan Hasil Praktikum Enzim Katalase.....	90
Gambar 4.11 Tampilan Menu Evaluasi.....	91
Gambar 4.12 Rata-Rata Persentase Skor Pretest dan Posttest pada Setiap Indikator Kemampuan Berpikir Kritis.....	102
Gambar 4.13 Rata-Rata Persentase Skor Pretest dan Posttest pada Setiap Indikator Keterampilan Proses Sains.....	111

DAFTAR LAMPIRAN

	Halaman
Lampiran A. Instrumen Penelitian	146
A.1 Soal Kemampuan Berpikir Kritis.....	153
A.2 Soal Keterampilan Proses Sains.....	160
A.3 Angket Uji Keterbacaan.....	169
A.4 Rencana Pelaksanaan Pembelajaran (RPP).....	171
Lampiran B. Data Penelitian	175
B.1 Hasil Validasi Ahli Media.....	176
B.2 Analisis Data Hasil Validasi Ahli Media.....	178
B.3 Hasil Validasi Ahli Materi.....	179
B.4 Analisis Data Hasil Validasi Ahli Materi.....	173
B.5 Data Uji Keterbacaan.....	182
B.6 Tampilan Laboratorium Virtual Enzim Katalase Sebelum Dan Sesudah Validasi.....	184
B.7 Skor Pretest Kemampuan Berpikir Kritis Siswa.....	185
B.8 Skor Posttest Kemampuan Berpikir Kritis Siswa.....	189
B.9 N-Gain Kemampuan Berpikir Kritis Siswa.....	193
B.10 Skor Pretest Keterampilan Proses Sains Siswa.....	195
B.11 Skor Posttest Keterampilan Proses Sains Siswa.....	199
B.12 N-Gain Keterampilan Proses Sains Siswa.....	203
B.13 Hasil Angket Tanggapan Guru Mengenai Pembelajaran Menggunakan Laboratorium Virtual Enzim Katalase.....	205
B.14 Analisis Data Angket Tanggapan Guru.....	207
Lampiran C. Dokumen Pendukung Penelitian	208
C.1 Surat Izin Penelitian.....	209
C.2 Surat <i>Judgment</i> Instrumen Penelitian.....	210
C.3 Panduan Penggunaan “Laboratorium Virtual Enzim Katalase”.....	211
C.4 Sertifikat Hak Kekayaan Intelektual (HKI) “Laboratorium Virtual Enzim Katalase”.....	219

Nadia, 2021

**PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK
MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA**
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

DAFTAR PUSTAKA

- Abdullah, N., Noh, N. M., Teck, W. K., & Hamzah, M. (2016). Pembinaan dan Penilaian Makmal Maya (Nora VLab) untuk Menerapkan Kemahiran Proses Sains dalam Kalangan Murid. *Jurnal Pendidikan Sains & Matematik Malaysia*, 6(2), 17–31.
- Abramov. V., Kugurakova. V., Rizvanov. A., Abramskiy. M., Manakhov. N., Evstafiev. M., & Ivanov. D. (2017). Virtual Biotechnological Lab Development. *BioNanoScience*, 7(2), 363–65. doi: <http://dx.doi.org/10.1007/s12668-016-0368-9>
- Achor, E. E., Odoh, C. O., & Abakpa, V. O. (2018). Use of Investigative Laboratory Strategy in Enhancing Acquisition of Science Process Skills Among Senior Secondary Biology Students. *Journal of Research in Curriculum and Teaching*, 1(1), 103–109.
- Adeyemi, S. B. (2012). Developing Critical Thinking Skills in Students: A Mandate for Higher Education in Nigeria. *European Journal of Educational Research*, 1(2), 155–161. doi: <https://doi.org/10.12973/eu-jer.1.2.155>
- Agnafia, D. N. (2019). Analisis Kemampuan Berpikir Kritis Siswa dalam Pembelajaran Biologi. *Florea*, 6(1), 45–53.
- Aini, K., Megawati, & Rojayanti, N. (2021). Membekalkan Pengetahuan Prosedural dan Sikap Ilmiah Kepada Siswa SMA Melalui Pembelajaran Virtual Laboratory. *BioEuin*, 11(1), 39–48.
- Aldoobie, N. (2015). ADDIE Model. *American International Journal of Contemporary Research*, 5(6), 68–72.
- Aljuhani, Khulood, Sonbul, M., Alhabiti. M., & Meccawy. (2018). Creating a Virtual Science Lab (VSL): The Adoption of Virtual Labs in Saudi Schools. *Smart Learning Environments*, 5(16). doi: <https://doi.org/10.1186/s40561-018-0067-9>
- Alkhalidi, T., Pranata, I., & Athauda, R. I. (2016). A Review of Contemporary Virtual and Remote Laboratory Implementations: Observations and Findings. *Journal of Computers in Education*, 3(3), 329–351. doi: <https://doi.org/10.1007/s40692-016-0068-z>
- Alsarayreh, R. S. (2021). Developing Critical Thinking Skills Towards Biology Course Using Two Active Learning Strategies. *Cypriot Journal of Educational Sciences*, 16(1), 221–237. doi: <https://doi.org/10.18844/cjes.v16i1.5521>
- Andrini, V. S. (2016). The Effectiveness of Inquiry Learning Method to Enhance Students ' Learning Outcome : A Theoretical and Empirical Review. *Journal of Education and Practice*, 7(3), 38–42.

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Anindhyta, C., Sunarno, W., & Budiawanti, S. (2021). Physics Virtual Learning Simulation to Enhance Students' Critical Thinking Skill : Virtual Learning during the COVID-19 Pandemic. *Journal of Hunan University (Natural Sciences)* , 48(5), 157–163.
- Annisa, L., Oktaviana, C., & Habibi, A. A. (2020). Hubungan Keterampilan Berpikir Kritis Dengan Hasil Belajar Peserta Didik. *EDUBIOLOGICA Jurnal Penelitian Dan Pendidikan Biologi*, 8(1), 35–37.
- Arikunto, S. (2008). *Penilaian Program Pendidikan*. Jakarta: Bina Aksara.
- Arikunto, S. (2013). *Dasar-dasar Evaluasi Pendidikan Edisi kedua*. Jakarta: Bumi Aksara.
- Aripin, I., & Suryaningsih, Y. (2020). Developing BTEM-Based Virtual Biology Laboratory to Improve Students' Critical Thinking Skills on the Concept of Bacteria. *Scientiae Educatia*, 9(2), 216-277. doi: <https://doi.org/10.24235/sc.educatia.v9i2.7379>
- Artun, H., Durukan, A., & Temur, A. (2020). Effects of Virtual Reality Enriched Science Laboratory Activities On Pre-Service Science Teachers' Science Process Skills. *Education and Information Technologies*, 1–22. doi: <https://doi.org/10.1007/s10639-020-10220-5>
- Ash, D. (2000). *The Process Skills of Inquiry* (Foundations, Volume 2: Inquiry: Thoughts, Views, and Strategies for the K-5 Classroom).
- Askar, A., Daud, F., & Syamsiah. (2018). Pengembangan Lembar Kerja Peserta Didik berbasis Inkuiri Terbimbing pada Materi Sistem Pencernaan Kelas XI SMA. *Jurnal Biology Teaching and Learning*, 2(2), 142–151.
- Asrizal, A., Hendri, A., Hidayati, & Festiyed. (2018). "Penerapan Model Pembelajaran Penemuan Mengintegrasikan Laboratorium Virtual dan HOTS untuk Meningkatkan Hasil Pembelajaran Siswa SMA Kelas XI". *Prosiding Seminar Nasional Hibah Program Penugasan Dosen Ke Sekolah (PDS)* (hlm. 49–57). Padang: Universitas Negeri Padang.
- Astika, E., Anggraeni, S & Supriatno, B. (2020). Analisis Komponen Penyusun Desain Kegiatan Laboratorium Enzim Katalase. *Biodik*, 6(3), 343–356. doi: <https://doi.org/10.22437/bio.v6i3.9469>
- Astutik, S., Susantini, E., MADladzim, & Nur, M. (2017). Effectiveness of Collaborative Students Worksheet To Improve Student' S Affective Scientific Collaborative and Science Process Skills (SPS). *International Journal of Education and Research*, 5(1), 151–164.
- Azizaturedha, M., Fatmawati, S., & Yuliani, H. (2019). Penerapan Model Pembelajaran Inkuiri Terbimbing dengan Media Laboratorium Virtual (PhET) untuk Meningkatkan Hasil Belajar, Keterampilan Proses Sains dan Minat

Belajar Siswa pada Pokok Bahasan Elastisitas. *EduFisika: Jurnal Pendidikan Fisika*, 4(1), 1–5.

- Azrai, E. P., Suryanda, A., Wulaningsih, R. D., & Sumiyati, U. K. (2020). Kemampuan Berpikir Kritis dan Literasi Sains Siswa SMA di Jakarta Timur. *Edusains*, 12(1), 89–97.
- Barker, M., Olabbarriaga, S. D., Wilkins-Diehr, N., Gesing, S., Katz, D. S., Shahand, S., Henwood, S., Glatard, T., Jeffery, K., Corrie, B., Treloar, A., Glaves, H., Wyborn, L., Hong, N. P. C., & Costa, A. (2019). The Global Impact of Science Gateways, Virtual Research Environments and Virtual Laboratories. *Future Generation Computer Systems*, 95, 240–248. doi: <https://doi.org/10.1016/j.future.2018.12.026>
- Berg, J. M., Tymoczko, J. L., Jr, G. J. G., & Stryer, L. (2015). *Biochemistry* (Eighth). W. H. Freeman and Company.
- Budai, T., & Kuczmann, M. (2018). Towards A Modern, Integrated Virtual Laboratory System. *Acta Polytechnica Hungarica*, 15(3), 191–204. doi: <https://doi.org/10.12700/APH.15.3.2018.3.11>
- Budhiman, A., Ellianawati, E., & Wahyuni, S. (2021). Implementation of Science Virtual Class Based Schoology in Improving Students' Critical Thinking Skill. *Journal of Innovative Science Education*, 10(2), 209–215. doi: <http://journal.unnes.ac.id/sju/index.php/jise>
- Branch, R. M. (2009). *Intructional Design: The ADDIE Approach*. Berlin: Spinger.
- Burns, J. C., Okey, J. R., & Wise, K. C. (1985). Development of an Integrated Process Skill Test: TIPS II. *Journal of Research in Science Teaching*, 22(2), 169–177. doi: <https://doi.org/10.1002/tea.3660220208>
- Cahyaningrum, I., Mursiti, S., Sumarni, W., & Harjono. (2020). Pengaruh Praktikum Berbasis Guided Inquiry berbantuan Virtual Lab Terhadap Keterampilan Proses Sains. *Chemistry in Education*, 9(1), 1–8. doi: <https://doi.org/10.1111/j.1949-8594.1902.tb00418.x>
- Çakiroğlu, Ü., Güven, O., & Saylan, E. (2020). Flipping The Experimentation Process: Influences On Science Process Skills. *Educational Technology Research and Development*, 68(6), 3425–3448. doi: <https://doi.org/10.1007/s11423-020-09830-0>
- Campbell, N. A. & J. B. Reece. (2010). *Biologi*. Jilid 1. Edisi Kedelapan. Alih Bahasa: Wasmen. Jakarta: Penerbit Erlangga.. Jakarta: Erlangga.
- Chatwattana, P., & Phadungthin, R. (2019). Web-based Virtual Laboratory for The Promotion of Self-directed Learning. *Global Journal of Engineering Education*, 21(2), 157–164.

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Chen, S. (2010). The View Of Scientific Inquiry Conveyed By Simulation-Based Virtual Laboratories. *Computers and Education*, 55, 1123–1130. doi: <https://doi.org/10.1016/j.compedu.2010.05.009>
- Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2017). 21st Century Skills Development Through Inquiry-Based Learning. In *21st Century Skills Development Through Inquiry-Based Learning: From Theory to Practice* (Issue August 2018). Springer Nature.
- Coffman, T. (2017). *Inquiry-Based Learning* (Third). Rowman & Littlefield.
- Cottrell, S. (2005). Critical Thinking Skills. Developing Effective Analysis and Argument. In *Contemporary Nurse* (Vol. 25, Issues 1–2). PALCRAVE MACMILLAN. <https://doi.org/10.5172/conu.2007.25.1-2.174a>
- Cruz, J. P. C. dela. (2015). "Development of An Experimental Science Module to Improve Middle School Students' Integrated Science Process Skills". *Proceedings of the DLSU Research Congress* (hlm. 1-6). Manila: De La Salle University.
- Damopolii, I., Hasan, A., & Kandowangko, N. (2015). Pengaruh Strategi Pembelajaran Inkuiri dan Kemampuan Memecahkan Masalah Terhadap Keterampilan Proses Sains Mahasiswa pada Praktikum Fisiologi Tumbuhan. *Pancaran*, 4(3), 191-200.
- Daniah, D. (2020). Pentingnya Inkuiri Ilmiah pada Praktikum dalam Pembelajaran IPA untuk Peningkatan Literasi Sains Mahasiswa. *PIONIR Jurnal Pendidikan*, 9(1), 144–153. doi: <https://doi.org/http://dx.doi.org/10.22373/pjp.v9i1.7178>
- Delson, D. L., & Cox, M. M. (2017). *Lehninger Principles of Biochemistry* (Seventh). W. H. Freeman and Company. doi: <https://doi.org/10.1097/SCS.0b013e3182319846>
- Devi, A. J., & Muthukumar, R. (2016). Tele-immersion. *International Journal of Informatics and Communication Technology (IJ-ICT)*, 5(2), 73–78.
- Duruk, U., Akgün, A., Dogan, C., & Gülsuyu, F. (2017). Examining the Learning Outcomes Included in the Turkish Science Curriculum in Terms of Science Process Skills: A Document Analysis with Standards-Based Assessment. *International Journal of Environmental and Science Education*, 12(2), 117–142.
- Dyrberg, N. R., Treusch, A. H., & Wiegand, C. (2016). Virtual Laboratories in Science Education: Students' Motivation and Experiences in Two Tertiary Biology Courses. *Journal of Biological Education*, 51(4), 1–17. doi: <https://doi.org/10.1080/00219266.2016.1257498>
- Egbutu, Rita, N., & Okeke. (2021). Effects of Computer Animation and Inquiry Method on Chemistry Students' Critical Thinking and Achievement in Onitsha Education Zone. *IOSR Journal of Research & Method in Education (IOSR-JRME)*, 11(2). doi: <https://doi.org/10.9790/7388-1102034248>

- Ekici, M., & Erdem, M. (2020). Developing Science Process Skills through Mobile Scientific Inquiry. *Thinking Skills and Creativity*, 36, 1–12. doi: <https://doi.org/10.1016/j.tsc.2020.100658>
- Ennis, R. H. (1996). Critical Thinking Dispositions: Their Nature and Assessability. *Informal Logic*, 18(2), 165–182. doi: <https://doi.org/10.22329/il.v18i2.2378>
- Ennis, R. H. (2015). The Nature of Critical Thinking: Outlines of General Critical Thinking Disposition and Abilities. [Online]. Diakses dari <http://criticalthinking.net/wp-content/uploads/2018/01/The-Nature-of-Critical-Thinking.pdf>
- Ervina. (2020). *Kemampuan Berpikir Kritis dan Pemahaman NoS Calon Guru dan Guru Biologi Melalui Virtual Lab dalam Kegiatan Praktikum*. (Tesis). Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Bandung.
- Febri, A., Sajidan, Sarwanto, & Harjunowibowo, D. (2020). Guided Inquiry Lab: Its Effect to Improve Student's Critical Thinking on Mechanics. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 9(1), 87–97. doi: <https://doi.org/10.24042/jipfalbiruni.v9i1.4630>
- Fischer, C., & Dersheimer, R. C. (2020). "Preparing Teachers to Use Educational Games, Virtual Experiments, and Interactive Science Simulations for Engaging Students in The Practices of Science". *Conference: Proceedings of the 20th International Conference on Multimedia in Physics Teaching and Learning* (hlm. 263-270). Munich: European Physical Society.
- Fisher, A. (2011). *Critical Thinking: An Introduction* (Edisi Kedua). Cambridge University Press.
- Fonna, T. M., Adlim, A., & Ali S, M. (2013). Perbedaan Keterampilan Berpikir Kritis Siswa Melalui Penerapan Media Pembelajaran Laboratorium Virtual Pada Konsep Sistem Pernapasan Manusia Di SMA Negeri Unggul Sigli. *BIOTIK: Jurnal Ilmiah Biologi Teknologi Dan Kependidikan*, 1(2), 67–136. doi: <https://doi.org/10.22373/biotik.v1i2.223>
- Fraenkel, J. R., Wallen, N. E., & Hyum, H. H. (2005). *How to Design and Evaluate Research in Education* (Edisi Kedelapan). New York: Mc. Graw Hill.
- Friesen, S. (2013). *Inquiry-Based Learning: A Review of the Research Literature* (Issue June).
- Gilbert, S. W. (2011). *Models Based Science Teaching*. NSTA Press.
- Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving Junior High Schools' Critical Thinking Skills Based on Test Three Different Models of Learning. *International Journal of Instruction*, 10(1), 101–116. doi: <https://doi.org/10.12973/iji.2017.1017a>

- Funk, J. (1985). *Learning Science Process Skills*. Dubuque: Kendall/Hunt Publishing Company.
- Gabel, D. L. (1992). *Introductory Science Skills* (Edisi Kedua). Illinois: Waveland Pr Inc.
- Gafar, A. arif, & Sugandi, M. kurnia. (2019). Pengembangan Perangkat Media Pembelajaran Partikum Virtual Untuk Meningkatkan Keterampilan Proses Sains Siswa Kelas X SMAN 1 Sindangwangi Kab. Majalengka. *Jurnal Biotek*, 7(2), 96–110. website: <http://journal.uin-alauddin.ac.id/index.php/biotek/index>
- Goudsouzian, L. K., Riola, P., Ruggles, K., & Mondoux, A. (2018). Article Integrating Cell and Molecular Biology Concepts : Comparing Learning Gains and Self-Efficacy in Corresponding Live and Virtual Undergraduate Laboratory. *Biochemistry and Molecular Biology Education*, 46(4), 361–372. doi: <https://doi.org/10.1002/bmb.21133>
- Goyal, M. M., & Basak, A. (2010). Human Catalase: Looking for Complete Identity. *Protein and Cell*, 1(10), 888–897. doi: <https://doi.org/10.1007/s13238-010-0113-z>
- Grimaldi, D., & Rapuano, S. (2009). Hardware and Software to Design Virtual Laboratory for Education in Instrumentation and Measurement. *Measurement: Journal of the International Measurement Confederation*, 42(4), 485–493. doi: <https://doi.org/10.1016/j.measurement.2008.09.003>
- Gunawan, Harjono, A., Hermansyah, & Herayanti, L. (2019). Guided Inquiry Model Through Virtual Laboratory to Enhance Students' Science Process Skills on Heat Concept. *Cakrawala Pendidikan*, 38(2), 259–268. doi: <https://doi.org/10.21831/cp.v38i2.23345>
- Gunawan, & Liliyasi. (2012). Model Virtual Laboratory Fisika Modern untuk Meningkatkan Disposisi Berpikir Kritis Calon Guru. *Jurnal Cakrawala Pendidikan*, 2, 185–199. doi: <https://doi.org/10.21831/cp.v5i2.1556>
- Hake, R.R. (1998). Interactive-engagement Vs. Traditional Methods: A six-thousand-student Survey of Mechanics Test Data for Introductory Physics Courses. *American Journal of Physics*, 66(1), 64-74.
- Hansson, T. (2008). *Handbook of Research on Digital Information Technologies: Innovations, Methods, and Ethical Issues*. Pennsylvania: IGI Global.
- Hao, C., Zheng, A., Wang, Y., & Jiang, B. (2021). Experiment Information System Based on an Online Virtual Laboratory. *Future Internet 2021*, 13(27), 1–19. doi: <https://doi.org/https://doi.org/10.3390/fi1302002>
- Harlen, W. (1999). Assessment in Education : Principles , Policy & Practice Purposes and Procedures for Assessing Science Process Skills. *Assessment in*

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

Education, 6(1), 129–144. doi: <https://doi.org/10.1080/09695949993044>

Hasan, I., & Madlazim. (2018). The Application Of Virtual Greenhouse Effect Laboratory on The Material Of Global Warming Symptoms To Improve Students' Science Process Skills. *Jurnal Inovasi Pendidikan Fisika*, 7(2), 106–109.

Heleri, Situmorang, R. P., & Dewi, L. (2019). The Development of Free Inquiry Lab-Based Students Worksheet to Increase the Dimension in Science Literacy Process. *Jurnal Pendidikan Indonesia*, 8(2), 188–197. doi: <https://doi.org/10.23887/jpi-undiksha.v8i2.17573>

Helm, D. R., Kosinski, C. W. . H. R. J., & Cummings, J. R. (1996). *Biology in the Laboratory* (Third). W. H. Freeman and Company.

Herga, N. R., & Dinevski, D. (2012). Virtual Laboratory in Chemistry - Experimental Study of Understanding, Reproduction and Application of Acquired Knowledge of Subject's Chemical Content. *Organizacija*, 45(3), 108–116. doi: <https://doi.org/10.2478/v10051-012-0011-7>

Hernawati, A., & Nurbayani, S. (2018). "The Importance of Critical Thinking to Face Global Challenges in The Era of Industry 4.0 Through Social Studies". *The 3rd International Seminar on Social Studies and History Education (ISSSHE)* 2018 (hlm. 155–166). Bandung: Universitas Pendidikan Indonesia.

Herrani, C. R. (2015). Penggunaan Vitual Lab untuk Meningkatkan Keterampilan Mahasiswa Biologi dalam Menggunakan Alat-alat Mikrobiologi. *Widya Dharma Jurnal Kependidikan*, 27(2), 160–174.

Hidayat, A., & Gayuh Utomo, V. (2015). Virtual Laboratory Implementation To Support High School Learning. *International Journal of Computer Applications*, 120(16), 14–18. doi: <https://doi.org/10.5120/21310-4283>

Hindriana, A. F. (2016). The Development of Biology Practicum Learning Based on Vee Diagram for Reducing Student Cognitive Load. *JETL (Journal Of Education, Teaching and Learning)*, 1(2), 61–65. doi: <https://doi.org/10.26737/jetl.v1i2.39>

Hindriana, A. F. (2020). Pengembangan Lembar Kerja Praktikum Berbasis Diagram Vee Guna Memfasilitasi Kegiatan Laboratorium Secara Bermakna. *Quagga: Jurnal Pendidikan Dan Biologi*, 12(1), 62–68. doi: <https://doi.org/10.25134/quagga.v12i1.2331>

Hizbi, T. (2019). Pengaruh Metode Demonstrasi Menggunakan Laboratorium Virtual dan Riil Terhadap Keterampilan Proses Sains Siswa. *Kappa Journal*, 3(1), 50–57.

Ikhsan, J., Sugiyarto, K. H., & Astuti, T. N. (2020). Fostering Student's Critical Thinking Through A Virtual Reality Laboratory. *International Journal of*

Interactive Mobile Technologies, 14(8), 183–195. doi: <https://doi.org/10.3991/IJIM.V14I08.13069>

Ilma, S., Al-Muhdhar, M. H. I., Rohman, F., & Saptasari, M. (2020). The Correlation Between Science Process Skills and Biology Cognitive Learning Outcome of Senior High School Students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(1), 55–64. doi: <https://doi.org/10.22219/jpbi.v6i1.10794>

Inayah, A. D., Ristanto, R. H., Sigit, D. V., & Miarsyah, M. (2020). Analysis of Science Process Skills in Senior High School Students. *Universal Journal of Educational Research*, 8(4A), 15–22. doi: <https://doi.org/10.13189/ujer.2020.081803>

İnce, E., Kırbaşlar, F. G., Güneş, Z. Ö., Yaman, Y., Yolcu, Ö., & Yolcu, E. (2015). An Innovative Approach in Virtual Laboratory Education: The Case of “IUVIRLAB” and Relationships between Communication Skills with the Usage of IUVIRLAB. *Procedia - Social and Behavioral Sciences*, 195, 1768–1777. doi: <https://doi.org/10.1016/j.sbspro.2015.06.377>

Indri, O. W., Sarwanto, & Nurosyid, F. (2020). Analysis of High School Students’ Science Process Skills. *Journal of Physics: Conference Series*, 1567, 1-4. doi: <https://doi.org/10.1088/1742-6596/1567/3/032098>

Iovan, M., Surianu, F. D., & Molnar-Matei, F. (2015). Virtual Laboratory for Power Quality Study. *Procedia - Social and Behavioral Sciences*, 191, 2798–2802. doi: <https://doi.org/10.1016/j.sbspro.2015.04.438>

Irwansyah, M., Ferawati, F., Suryani, E., Olahairullah, O., Ariyansyah, A., Nurfathurrahmah, N., & Rubianti, I. (2020). Developing Biology Learning Tools Based on Character Education Integrated with Sustainable Local Wisdom to Enhance 21st-Century Attitude of Students. *Journal of Physics: Conference Series*, 1521, 1-5. doi: <https://doi.org/10.1088/1742-6596/1521/4/042017>

Jannah, M., Khaldun, I., & Safrida, S. (2021). Application of Virtual Laboratory assisted Discovery Learning Model to Improve Science Process Skills and Learning Outcomes in Circulatory System Material. *Jurnal Penelitian Pendidikan IPA*, 7(1), 34–40. doi: <https://doi.org/10.29303/jppipa.v7i1.470>

Jeenthong, T., Ruenwongsa, P., & Sriwattanarothai, N. (2014). Promoting Integrated Science Process Skills Through Betta-live Science Laboratory. *Procedia - Social and Behavioral Sciences*, 116, 3292–3296. doi: <https://doi.org/10.1016/j.sbspro.2014.01.750>

Johanson, L. (2019). An Introduction to Critical Thinking. *Nursing*, 49(6), 42-43. doi: <https://doi.org/10.1097/01.NURSE.0000558090.23346.fb>

Kalemkuş, J., Bayraktar, Ş., & Çiftçi, S. (2021). Comparative Effects of Argumentation and Laboratory Experiments on Metacognition, Attitudes, and

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

Science Process Skills of Primary School Children. *Journal of Science Learning*, 4(2). doi: <https://doi.org/10.17509/jsl.v4i2.27825>

Karagöz, Ö., & Saka, A. Z. (2015). Development of Teacher Guidance Materials Based On 7E Learning Method In Virtual Laboratory Environment. *Procedia - Social and Behavioral Sciences*, 191, 810–827. doi: <https://doi.org/10.1016/j.sbspro.2015.04.524>

Karupaiah, T., & Daniel, E. G. S. (2021). Inter-School Synchronous Peer Collaboration in Enhancing the Science Process Skills of Controlling Variables and Formulating Hypothesis Among Low Achieving Year Five Pupils. *Journal of ICT in Education (JICTIE)*, 8(1), 73–91. Kementerian Pendidikan dan Kebudayaan. (2003). *Sistem Pendidikan Nasional*. Jakarta: Kemendikbud.

Kementerian Pendidikan dan Kebudayaan. (2014). *Konsep dan Implementasi Kurikulum 2013*. Jakarta: Kemendikbud.

Kementerian Pendidikan dan Kebudayaan. (2018). *Permendikbud No. 24 tentang Kompetensi Inti dan Kompetensi Dasar Pelajaran pada Kurikulum 2013 pada Pendidikan Dasar dan Pendidikan Menengah*. Jakarta: Kemendikbud.

Khairuna, Rahmatan, H., Sarong, M. A., Supriatno, & Ulfa, A. (2021). Penerapan Model Discovery Learning dengan Pemanfaatan Virtual Laboratory untuk Meningkatkan Keterampilan Proses Sains dan Hasil Belajar Peserta Didik pada Materi Sistem Ekskresi. *Jurnal Pendidikan Sains Indonesia*, 9(2), 280–292. doi: <https://doi.org/10.24815/jpsi.v9i2.18875>

Kidman, G., & Casinader, N. (2017). Inquiry-Based Teaching and Learning Across Disciplines: Comparative Theory and Practice in Schools. In *Inquiry-Based Teaching and Learning across Disciplines: Comparative Theory and Practice in Schools*. Springer Nature. doi: <https://doi.org/10.1057/978-1-137-53463-7>

Klentien, U., & Wannasawade, W. (2016). Development of Blended Learning Model with Virtual Science Laboratory for Secondary Students. *Procedia - Social and Behavioral Sciences*, 217, 706–711. doi: <https://doi.org/10.1016/j.sbspro.2016.02.126>

Kumar, D., Sasidharakurup, H., Radhamani, R., Nizar, N., Krishnashree Achuthan, M., Nair, B., & Shyam Diwakar, S. (2015). "Mobile Learning and Biotechnology Education via Remote Labs : Deployment-Based Study on Real Time Shared Resources". *2015 International Conference on Interactive Mobile Communication Technologies and Learning (IMCL)* (hlm. 39–43).

Kumari, U. N., & Rao, D. B. (2008). *Science Process Skills Of School Students*. Discovery Publishing House.

Laelasari, I., & Supriatno, B. (2018). Analisis Komponen Penyusun Desain Kegiatan Laboratorium Bioteknologi. *Jurnal Bioedukatika*, 6(2), 84–90. doi:

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

<https://doi.org/10.26555/bioedukatika.v6i2.10592>

- Lawenda, M., Meyer, N., & Rajtar, T. (2002). General framework for Virtual Laboratory. In *The 2ND Cracow Grid Workshop* (Issue December).
- Lestari, R., Supriatno, B., & Anggraeni, S. (2020). Analisis Konseptual , Praktikal , Konstruksi Pengetahuan dan Rekonstruksi Lembar Kerja Praktikum Enzim Katalase. *BIODIK: Jurnal Ilmiah Pendidikan Biologi*, 6(4), 476–491.
- Lismaya, L. (2019). *Berpikir Kritis dan PBL (Problem Based Learning)*. Surabaya: Media Sahabat Cendekia.
- Lloyd, J. ., & Register, K. . (2003). *Virginia’s Water Resources: A tool for teachers*. Longwood University & Clean Virginia Waterways.
- Maemunah, S., & Pramesti, I. (2019). *Pengembangan Modul Jaringan Tumbuhan Berbasis Pendekatan Contextual Teaching and Learning (CTL)*. 2(2), 129–136.
- Maesaroh, Anugrah, D., Elvianasti, M., & Irdalisa. (2021). Jurnal Pendidikan Biologi. *Jurnal Pendidikan Biologi*, 10(1), 24–31.
- Manuel, P. M., Pilar, A. M., María Dolores, R. M., MP, D., Sara, P., & M. Pilar, M. J. (2019). Characterization of biodiesel using virtual laboratories integrating social networks and web app following a ubiquitous- and blended-learning. *Journal of Cleaner Production*, 215, 399–409. doi: <https://doi.org/10.1016/j.jclepro.2019.01.098>
- Maryuningsih, Y., Manfaat, B., & Riandi. (2019). Penerapan Laboratorium Virtual Elektroforesis Gel dan Polimerase Chain Reaction (PCR) Sebagai Pengganti Praktikum Rill. *Phenomenon : Jurnal Pendidikan MIPA*, 9(1), 48–64.
- Meilani, D., Dantes, N., & Tika, I. N. (2020). Pengaruh Implementasi Pembelajaran Saintifik Berbasis Keterampilan Belajar dan Berinovasi 4C terhadap Hasil Belajar IPA dengan Kovariabel Sikap Ilmiah pada Peserta Didik Kelas V SD Gugus 15 Kecamatan Buleleng. *Jurnal Elementary: Kajian Teori Dan Hasil Penelitian Pendidikan Sekolah Dasar*, 3(1), 1–5.
- Mercer, L., Prusinkiewicz, P., & Hanan, J. (1990). Concept and design of a virtual laboratory. *Proceedings - Graphics Interface*, 149–155.
- Millar, R. (2004). *The Role of Practical Work in The Teaching and Learning of Science*. Washington, D.C.: National Academy of Sciences.
- Millar, R. (2018). *Professional Development for Inquiry-Based Science Teaching and Learning* (O. E. Tsivitanidou, P. Gray, E. Rybska, L. Louca, & C. C. P. (eds.)). Springer Nature.
- Miyamoto, M., Milkowski, D. M., Young, C. D., & Lebowicz, L. A. (2019). *Developing a Virtual Lab to Teach Essential Biology Laboratory Techniques*. Nadia, 2021
- PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA**
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

43(1), 23–31.

- Molefe, L. (2021). *Exploring How Science Process Skills Blend With The Scientific Process : Pre-service Teachers ' Views Following Fieldwork Experience*. 41(2), 1–13.
- Moon, J. (2008). *Critical Thinking: An Exploration of Theory and Practice*. New York: Routledge.
- Moore, B. N., & Parker, R. (2009). *Critical Thinking Highlights* (Edisi Kesembilan). New York: McGraw-Hil.
- Muhamad, M., Zaman, H. B., & Ahmad, A. (2012). Virtual Biology Laboratory (VLab-Bio): Scenario-Based Learning Approach. *Procedia - Social and Behavioral Sciences*, 69, 162–168. doi: <https://doi.org/10.1016/j.sbspro.2012.11.395>
- Muliawati, D. I., & Norra, B. I. (2021). The Influence of Quarted Card and Virtual Laboratory Media On Students' Critical Thinking Ability. *IOP Conference Series: Earth and Environmental Science*, 1796(1). doi: <https://doi.org/10.1088/1742-6596/1796/1/012121>
- Muskita, M., Subali, B., & Djukri. (2020). Effects of Worksheets Base The Levels of Inquiry In Improving Critical and Creative Thinking. *International Journal of Instruction*, 13(2), 519–532. doi: <https://doi.org/10.29333/iji.2020.13236a>
- Nadia, N., Supriatno, B., & Anggraeni, S. (2020). Analisis dan Rekonstruksi Komponen Penyusun Lembar Kerja Peserta Didik Struktur dan Fungsi Jaringan Tumbuhan. *Biodik*, 6(2), 82–94. doi: <https://doi.org/10.22437/bio.v6i2.9439>
- Najah, S. Z., & Setiati, N. (2020). Implementation of Cambridge International Curriculum Biology and the Impact on Critical Thinking Skills of Students in Semester High School. *Journal of Biology Education*, 9(1), 64–75. doi: <https://doi.org/10.15294/jbe.v9i1.38074>
- National Research Council. 2000. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, D.C.: The National Academies Press.
- Nugraha, A. J., Suyitno, H., & Susilaningsih, E. (2017). Analisis Kemampuan Berpikir Kritis Ditinjau dari Keterampilan Proses Sains dan Motivasi Belajar melalui Model PBL. *Journal of Primary Education*, 6(1), 35–43.
- Nur & Nasir. (2019). PKM Musyawarah Guru Mata Pelajaran (MGMP) IPA Terpadu di Kabupaten Wajo untuk Penerapan Model-Model Pembelajaran Kurikulum 2013 Revisi 2017. *Jurnal Pengabdian Kepada Masyarakat Sosiosaintifik (JurDikMas)*, 1(1), 1–8.

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Nuryanti, S., Masykuri, M., & Susilowati, E. (2019). Virtual Laboratory Development with Student's Worksheet to Improve Critical Thinking on Electrochemistry for Vocational School Students. *Journal of Physics: Conference Series*, 1233(1). doi: <https://doi.org/10.1088/1742-6596/1233/1/012016>
- Oladipo, A. J., & Margaret, A. (2020). Teachers' Awareness and Perceptions of Virtual Laboratories on Acquisition of Biology Practical. *Nigerian Online Journal of Educational Sciences and Technology (NOJEST)*, 1(1), 1–11.
- Omeodu, Oduh, & Nathaniel, V.-A. (2021). Significance of Field Trip on Biology Students Acquisition of Science Process Skills in Abua / Odual Local Government Area. *International Journal of Innovative Social & Science Education Research*, 9(1), 37–45.
- Padilla, M. J. (1990). The Science Process Skills. In *Research Matters - to the Science Teacher*. <https://narst.org/research-matters/science-process-skills>
- Padman, V., & Memon, N. (2002). "Design of A Virtual Laboratory for Information Assurance Education and Research". *Proceedings of the 2002 IEEE* (hlm. 1-7). New York: United States Military Academy, West Point.
- Paul, R. W., & Elder, L. (2002). *Critical Thinking: Tools for Taking Charge of Your Professional and Personal Life*. New Jersey: Prentice Hall.
- Permana, N. A., Widiyatmoko, A., & Taufiq, M. (2016). Pengaruh Virtual Laboratory Berbasis Flash Animation terhadap Pemahaman Konsep dan Keterampilan Berpikir Kritis Peserta Didik Tema Optik Kelas VIII SMP. *Unnes Science Education Journal*, 5(3), 1354–1365.
- Popović, N., & Naumović, M. B. (2016). Virtual Laboratory and Learning Management System in Optimal Control Theory Education. *International Journal of Electrical Engineering and Education*, 53(4), 357–370. doi: <https://doi.org/10.1177/0020720916639321>
- Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., & Jovanović, K. (2016). Virtual Laboratories For Education In Science, Technology, And Engineering: A Review. *Computers and Education*, 95, 309–327. doi: <https://doi.org/10.1016/j.compedu.2016.02.002>
- Puig, B., Blanco-Anaya, P., & Pérez-Maceira, J. J. (2021). "Fake News" or Real Science? Critical Thinking to Assess Information on COVID-19. *Frontiers in Education*, 6, 1–10. doi: <https://doi.org/10.3389/educ.2021.646909>
- Putri, N. E., Yolida, B., & Sikumbang, D. (2019). Hubungan Pelaksanaan Praktikum dan Keterampilan Proses Sains Terhadap Hasil Belajar Peserta Didik. *Jurnal Bioterdidik*, 7(4), 92–103.
- Quesada, V. (2020). Virtual laboratory Lessons in Enzymology. *Biochemistry and*

Molecular Biology Education, 48(5), 1–6. doi: <https://doi.org/10.1002/bmb.21394>

- Radhamani, R., Kumar, D., Nizar, N., Achuthan, K., Nair, B., & Diwakar, S. (2021). What Virtual Laboratory Usage Tells Us About Laboratory Skill Education Pre- and Post-COVID-19: Focus on Usage, Behavior, Intention and Adoption. *Education and Information Technologies*. doi: <https://doi.org/10.1007/s10639-021-10583-3>
- Raj, R. G., & Devi, S. N. (2014). Science Process Skills And Achievement in Science Among High School Student. *Scholarly Research Journal For Interdisciplinary Studies*, 2(25), 2435–2443.
- Ramdani, F. (2020). *Pengembangan Laboratorium Virtual Mikrobiologi Pangan untuk Meningkatkan High Order Thinking Skill Mahasiswa*. (Tesis). Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Bandung.
- Rasyida, N., Tapilouw, F., & Priyandoko, D. (2015). "Efektivitas Pengembangan Praktikum Virtual untuk Meningkatkan Kemampuan Berpikir Kritis dan Sikap Ilmiah Siswa SMA pada Konsep Metagenesis Tumbuhan Lumut dan Paku". *Prosiding Seminar Nasional Pendidikan Biologi 2015* (hlm. 267–275). Malang: Universitas Muhammadiyah Semarang.
- Rauf, R. A. A., Rasul, M. S., Mansor, A. N., Othman, Z., & Lyndon, N. (2013). Inculcation of Science Process Skills in A Science Classroom. *Asian Social Science*, 9(8), 47–57. doi: <https://doi.org/10.5539/ass.v9n8p47>
- Riduwan. (2012). *Skala Pengukuran Variabel-variabel Penelitian*. Bandung: Alfabeta.
- Rokhim, D. A., Asrori, M. R., & Widarti, H. R. (2020). Pengembangan Virtual Laboratory Pada Praktikum Pemisahan Kimia Terintegrasi Telefon Pintar. *JKTP: Jurnal Kajian Teknologi Pendidikan*, 3(2), 216–226. doi: <https://doi.org/10.17977/um038v3i22020p216>
- Rosdianti, V. I., & Paidi. (2021). Pengembangan Media Virtual Laboratory Untuk Meningkatkan Pemahaman Keterampilan Proses Sains Materi Histologi Hewan. *Spizaetus : Jurnal Biologi Dan Pendidikan Biologi*, 1–11.
- Rusliati, E., & Retnowati, R. (2019). Inkuiri Terbimbing pada Laboratorium Virtual dan Rill untuk Membangun Penguasaan Konsep dan Keterampilan Proses Sains. *Journal of Science Education and Practice*, 3(2), 33–41.
- Rustaman, N. (2007). *Keterampilan Proses Sains*. [Online]. Diakses dari http://file.upi.edu/Direktori/FPMIPA/JUR._PEND._BIOLOGI/195012311979032-NURYANI_RUSTAMAN/KPS_vs_KG.pdf.
- Salmerón-Manzano, E., & Manzano-Agugliaro, F. (2018). The Higher Education Sustainability Through Virtual Laboratories: The Spanish University as Case

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

of Study. *Sustainability (Switzerland)*, 10(11). doi: <https://doi.org/10.3390/su10114040>

Satriani, Taiyeb, M., & Mu'nisa. (2015). "Analisis Hubungan Pelaksanaan Praktikum dengan Keterampilan Proses Sains dan Hasil Belajar Biologi Peserta Didik SMA Negeri Di Kota Bulukumba". *Prosiding Seminar Nasional Biologi Dan Pembelajarannya* (hlm.141–148). Makassar: Universitas Negeri Makassar.

Schafersman, S. D. (1994). An Introduction to Science: Scientific Thinking and The Scientific Method. [Online]. Diakses dari <http://www.freeinquiry.com/intro-to-sci.html>.

Ścibior, D., & Czeczot, H. (2006). Catalase : Structure , Properties , Functions. *Postepy Hig Med Dosw*, 60, 170–180.

Sedumedi, T. D. T. (2017). Practical Work Activities as A Method of Assessing Learning in Chemistry Teaching. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(6), 1765–1784. doi: <https://doi.org/10.12973/eurasia.2017.00697a>

Setiono, Rustaman, N. Y., Rahmat, A., & Anggraeni, S. (2017). Implementasi Guided Inquiry Laboratorium Pada Praktikum Anatomi Tumbuhan. *Utile Jurnal Kependidikan*, 3(2), 195–201. doi: <https://doi.org/10.37150/jut.v3i2.77>

Shanti, W. N., Sholihah, D. A., & Martyanti, A. (2017). Meningkatkan Kemampuan Berpikir Kritis Melalui Problem Posing. *LITERASI (Jurnal Ilmu Pendidikan)*, 8(1), 49–59. doi: [https://doi.org/10.21927/literasi.2017.8\(1\).48-58](https://doi.org/10.21927/literasi.2017.8(1).48-58)

Siegel, H. (1980). Critical Thinking as an Educational Ideal. *The Educational Forum*, 45(1), 7-23. doi: <https://doi.org/10.1080/00131728009336046>

Simon, N. A. (2013). Simulated and Virtual Science Laboratory Experiments: Improving Critical Thinking and Higher-Order Learning Skills. (Dissertation). Northcentral University, San Diego. doi: <http://dx.doi.org/10.1016/j.jaci.2012.05.050>

Siswanto, S., Trisnowati, E., Firmadani, F., Haryati, S., Aryanti, D., & Andrianto, H. N. (2020). Workshop on Inquiry Learning Based Virtual Laboratory in Magelang for Preparing Natural Sciences Teacher in 21 St Century : an Evaluation of Implementation Program. *Indonesian Journal of Education and Learning*, 3(2), 367–373. doi: <https://doi.org/10.31002/ijel.v3i2.3036>

Slavin, R. E. (1992). *Research Methods in Education* (Edisi Kedua). Massachusetts: Allyn and Bacon.

Sotomayor-Moriano, J., Pérez-Zúñiga, G., & Soto, M. (2019). A Virtual Laboratory Environment for Control Design of a Multivariable Process. *IFAC-PapersOnLine*, 52(9), 218–223. doi:

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

<https://doi.org/10.1016/j.ifacol.2019.08.116>

- Sriarunrasmee, J., Suwannatthachote, P., & Dachakupt, P. (2015). Virtual Field Trips with Inquiry learning and Critical Thinking Process: A Learning Model to Enhance Students' Science Learning Outcomes. *Procedia - Social and Behavioral Sciences*, 197(February), 1721–1726. doi: <https://doi.org/10.1016/j.sbspro.2015.07.226>
- Stiggins. (1994). *Student-Centered Classroom Assessment*. New York : Merrill, an imprint of Macmillan College Publishing Company.
- Supriatno, B. (2013). *Pengembangan Program Perkuliahan Pengembangan Praktikum Biologi Sekolah Berbasis ANCORB untuk Mengembangkan Kemampuan Merancang dan Mengembangkan Desain Kegiatan Laboratorium*. Disertasi Jurusan Pendidikan Biologi FPMIPA UPI: Tidak diterbitkan.
- Supriatno, B. (2018). "Praktikum untuk Membangun Kompetensi". *Proceeding Biology Education Conference* (hlm. 1–18). Surakarta: Universitas Sebelas Maret.
- Suryaningsih, Y. (2017). Pembelajaran Berbasis Praktikum Sebagai Sarana Siswa untuk Berlatih Menerapkan Keterampilan Proses Sains dalam Materi Biologi. *Bio Educatio*, 2(2), 49–57.
- Suryanti, E., Fitriani, A., Redjeki, S., & Riandi, R. (2019). Virtual Laboratory as a Media to Improve The Conceptual Mastery of Molecular Biology. *Journal of Physics: Conference Series*, 1–4. doi: <https://doi.org/10.1088/1742-6596/1317/1/012202>
- Susilawati, P. R. (2019). Implementation of Web-Based Virtual Laboratory Media in Learning. *Jurnal Taman Vokasi*, 7(2), 122–128.
- Syahfitri, F. D., Manurung, B., & Sudibyoy, M. (2019). The Development of Problem Based Virtual Laboratory Media to Improve Science Process Skills of Students in Biology. *International Journal of Research & Review*, 6(6), 64–74.
- The Open University. (2008). *Thinking Critically*. Milton Keynes: The Open University.
- The Society for Biology. (2010). *The Importance of Practical Biology : from School to Higher Education*. [Online]. Diakses dari www.societyofbiology.org.
- Toohey, S., Ryan, G., & Hughes, C. (1996). Assessing The Practicum. *Assessment and Evaluation in Higher Education*, 21(3), 215–227. doi: <https://doi.org/10.1080/0260293960210302>
- Udin, W. N., Ramli, M., & Muzzazinah. (2020). Virtual laboratory for enhancing

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

students' understanding on abstract biology concepts and laboratory skills: A systematic review. *Journal of Physics: Conference Series*, 1521(4). doi: <https://doi.org/10.1088/1742-6596/1521/4/042025>

Ulfa, S. W. (2016). Pembelajaran Berbasis Praktikum: Upaya Mengembangkan Sikap Ilmiah Siswa pada Pembelajaran Biologi. *Jurnal Pendidikan Islam dan Teknologi Pendidikan*, 6(1), 65–75.

UNESCO. (2013). Introduction to Inquiry An Online Course for Teachers to Learn about the Inquiry Learning Cycle. [Online]. Diakses dari http://www.unesco.org/new/fileadmin/MULTIMEDIA/FIELD/Venice/pdf/special_events/Mini-course_print_en.pdf.

Utami, D. N., Widowati, A., & Wibowo, W. S. (2017). Pengembangan Media Virtual Laboratory IPA Materi Global Warming Berpendekatan Inkuiri untuk Meningkatkan Kemampuan Analisis Siswa Kelas VII. *Jurnal Pendidikan Matematika dan Sains*, 1, 1–6.

Vasiliadou, R. (2020). Virtual Laboratories During Coronavirus (COVID-19) Pandemic. *Biochemistry and Molecular Biology Education*, 48(5), 482–483. doi: <https://doi.org/10.1002/bmb.21407>

Wahidah, N. S., Supriatno, B., & Kusumastuti, M. N. (2018). Analisis Struktur dan Kemunculan Tingkat Kognitif pada Desain Kegiatan Laboratorium Materi Fotosintesis. *Indonesian Journal of Biology Education*, 1(2), 70–76.

Wale, B. D., & Bishaw, K. S. (2020). Effects of Using Inquiry-Based Learning On EFL Students' Critical Thinking Skills. *Asian-Pacific Journal of Second and Foreign Language Education*, 5(9), 1–14. doi: <https://doi.org/10.1186/s40862-020-00090-2>

Wenham, M. (2001). *200 Science Investigations for Young Students*. Paul Chapman Publishing L.td.

World Health Organization. (2021). Coronavirus. [Online]. Diakses dari https://www.who.int/health-topics/coronavirus#tab=tab_1

Widowati, A., Nurohman, S., & Setyowarno, D. (2017). Development of Inquiry-Based Science Virtual Laboratory for Improving Student Thinking Skill of Junior High School. *Jurnal Pendidikan Matematika Dan Sains*, 4(2), 170–177. doi: <https://doi.org/10.21831/jpms.v5i2.16708>

Wolf, T. (2010). Virtual Laboratory Environment. *IEEE Transactions on Education*, 53(2), 216–222.

Yang, H. H., & Yuen, S. C.-Y. (2010). *Handbook of Research on Practices and Outcomes in E-Learning: Issues and Trends*. IGI Global.

Nadia, 2021

PENGEMBANGAN LABORATORIUM VIRTUAL ENZIM KATALASE BERBASIS INKUIRI UNTUK MENINGKATKAN KEMAMPUAN BERPIKIR KRITIS DAN KETERAMPILAN PROSES SAINS SISWA
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Yap, W. H., Teoh, M. L., Tang, Y. Q., & Goh, B. H. (2021). Exploring The Use of Virtual Laboratory Simulations Before, During, and Post COVID-19 Recovery Phase: An Animal Biotechnology Case Study. *Biochemistry and Molecular Biology Education*, 1–7. doi: <https://doi.org/10.1002/bmb.21562>
- Yildirim, F. S. (2021). The Effect of Virtual Laboratory Applications on 8th Grade Students' Achievement in Science Lesson. *Journal of Education in Science, Environment and Health Volume*, 7(2), 171–181. website: <https://www.jeseh.net/index.php/jeseh/article/view/436>
- Yu, J., Brown, D., & Billet, E. (2005). Development of a Virtual Laboratory Experiment for Biology. *European Journal of Open, Distance and Elearning*, 1(195), 1–8. website: <http://www.eurodl.org>
- Yuniarti, A., Supriatno, B., & Nureni, E. (2018). "How to Improve The Science Process Skills of Biology Education Students on Photosynthesis Topic?". *International Conference on Mathematics and Science Education* (hlm.40–43). Bandung: Universitas Pendidikan Indonesia.
- Zhao, Yue. (2019). Construction of Virtual Simulation Laboratory in Higher Vocational Colleges. Dalam Sugumaran, V., Xu, Z., Shankar, P., & Zhou, H (Penyunting), *Aplication of Systems in Multi-modal Information Analytics* (hlm. 645–651). New York: Spinger.