

**KEDALAMAN DAN KELUASAN KONTEN BIOLOGI YANG
HARUS DIKUASAI OLEH GURU**

DISERTASI

Diajukan untuk Memenuhi Sebagian dari Syarat untuk Memperoleh Gelar Doktor
Pendidikan Ilmu Pengetahuan Alam



Oleh

Susanti Wulandari

NIM. 1802910

**PROGRAM STUDI PENDIDIKAN ILMU PENGETAHUAN ALAM
SEKOLAH PASCA SARJANA
UNIVERSITAS PENDIDIKAN INDONESIA
2022**

HALAMAN PENGESAHAN DISERTASI

Susanti Wulandari

**KEDALAMAN DAN KELUASAN KONTEN BIOLOGI YANG HARUS
DIKUASAI OLEH GURU**

Disetujui dan disahkan oleh panitia disertasi

Promotor



Prof. Dr. Hj. Nuryani Y. Rustaman, M.Pd.

NIP. 195012311979032019

Ko-Promotor



Prof. Dr. Phil. H. Ari Widodo, M.Ed.

NIP. 1967052719922031001

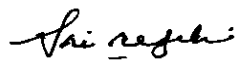
Anggota



Prof. Dr. I Nyoman Pugeg Aryantha, M.Sc.

NIP. 196505221990011002

Penguji:



Prof. Dr. Sri Redjeki, M.Pd.

Penguji



Dr. Didik Priyandoko, M.Si

NIP. 196912012001121001

Mengetahui,

Ketua Program Studi di Pendidikan IPA
Sekolah Pascasarjana Universitas Pendidikan Indonesia



Dr. Ida Kaniawati, M. Si.

NIP. 196807031992032001

Susanti Wulandari, 2022

Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

PERNYATAAN

Dengan ini saya menyatakan bahwa disertasi dengan judul “Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru” 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 resiko atau sanksi apabila di kemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

Bandung, 11 Januari 2022

Penulis,



Susanti Wulandari

KEDALAMAN DAN KELUASAN KONTEN BIOLOGI YANG HARUS DIKUASAI OLEH GURU

Susanti Wulandari (1802910)

ABSTRAK

Biologi sebagai ilmu yang terdiri dari fakta, konsep, prinsip, teori dan hukum terkait makhluk hidup dan prosesnya dipelajari mulai dari jenjang sekolah dasar hingga sekolah menengah. Terdapat enam bidang di dalam biologi di antaranya evolusi, ekologi, genetika, biologi sel, fisiologi, serta biosistemika dan taksonomi. Penguasaan konten menjadi salah satu indikator kompetensi profesional seorang guru. Penelitian tentang kedalaman dan keluasan konten biologi yang harus dikuasai oleh guru yang mengajar pada jenjang yang berbeda secara menyeluruh belum dilakukan. Studi kualitatif ini melibatkan 45 responden yang terdiri dari guru dan ahli. Tiga guru SD, tiga guru IPA, tiga guru biologi, dan masing-masing enam ahli dari enam bidang biologi dipilih secara teoritis dan sistematis untuk dilakukan wawancara secara mendalam. Wawancara dilakukan berdasarkan pada kesediaan responden sehingga terdapat berbagai metode pengambilan data, yakni wawancara langsung melalui tatap muka, telepon, *zoom meeting*, dan melalui kuesioner. Data yang diperoleh dianalisis mengikuti alur penelitian *grounded theory* yang terdiri *open coding*, *axial coding*, *selective coding*, dan teoritisasi. Berdasarkan hasil penelitian ditemukan bahwa guru SD perlu menguasai konsep-konsep dasar atau protokonep pada setiap bidang biologi dan mampu menyajikan materi secara konkret dengan konteks yang dapat diobservasi oleh siswa. Guru IPA yang mengajar pada jenjang SMP harus menguasai materi-materi biologi secara lebih luas dan mendalam hingga tahapan seluler dan menjangkau sub konsep-sub konsep dasar tersebut. Sementara, guru biologi yang mengajar pada jenjang SMA harus menguasai materi biologi secara lebih rinci hingga pada level molekuler. Dihasilkan suatu teori bahwa semakin tinggi jenjang pendidikan, maka semakin mendalam dan semakin luas pengetahuan konten biologi yang harus dikuasai guru.

Kata Kunci: kedalaman konten biologi, keluasan konten biologi, pengetahuan konten guru, *grounded-theory*

THE DEPTH AND BREADTH OF BIOLOGY CONTENT SHOULD BE MASTERED BY TEACHERS

Susanti Wulandari (1802910)

ABSTRACT

Biology as a field of science that consists of facts, concepts, principles, theories, and laws related to living things and their processes is studied from elementary school to high school. It has various themes including evolution, ecology, genetics, cell biology, physiology, and biosystematics, and taxonomy. Mastery of content describes one of the indicator of the professional competence of a teacher. Studies on the depth and breadth of biology content to be mastered by teachers at different levels have not been thoroughly carried out. This qualitative study involved 45 respondents consisting of teachers and experts. Three elementary school teachers, three science teachers, three biology teachers, and six experts from six biology fields were selected theoretically and systematically for in-depth interviews. The interviews were conducted based on the willingness of respondents so that there were various methods of data collection, namely direct interviews face-to-face, by telephone, Zoom Meetings, and questionnaires. The data obtained were analyzed following the grounded theory research flow consisting of open coding, axial coding, selective coding, and theorizing. Based on the findings, elementary school teachers should master the basic concepts or prototypes in each field of biology and be able to present material concretely in an observable context for students. Science teachers who teach at the junior high school level should master biology materials more broadly and deeply to the cellular stage and reach the sub concepts of each basic concept. Meanwhile, biology teachers who teach at the senior high school level should master biology material in more detail up to the molecular level. A theory is generated that the higher level of education requires teachers to master content knowledge that is more broadly and more deeply.

Keywords: depth of biology content, breadth of biology content, teacher content knowledge, grounded theory

Susanti Wulandari, 2022

Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

DAFTAR ISI

| Isi | Halaman |
|--|---------|
| HALAMAN PENGESAHAN..... | i |
| HALAMAN PERNYATAAN KEASLIAN DISERTASI | ii |
| KATA PENGANTAR | iii |
| UCAPAN TERIMA KASIH | iv |
| ABSTRAK | vi |
| <i>ABSTRACT</i> | vii |
| DAFTAR ISI | viii |
| DAFTAR TABEL | xi |
| DAFTAR GAMBAR | xiii |
| DAFTAR LAMPIRAN | xv |
| BAB I PENDAHULUAN | 1 |
| 1.1 Latar Belakang..... | 1 |
| 1.2 Rumusan Masalah Penelitian | 8 |
| 1.3 Pembatasan Masalah | 9 |
| 1.4 Tujuan Penelitian | 9 |
| 1.5 Manfaat Penelitian | 9 |
| 1.6 Struktur Organisasi Disertasi | 10 |
| BAB II KAJIAN PUSTAKA..... | 12 |
| 2.1 Kedalaman dan Keluasan Konten Biologi..... | 12 |
| 2.2 Proses Belajar dan Struktur Konten..... | 29 |
| 2.2.1 Proses Belajar..... | 29 |
| 2.2.2 Struktur Konten dan Konten Konseptual Biologi..... | 32 |
| BAB III METODE PENELITIAN | 40 |
| 3.1 Definisi Operasional..... | 40 |
| 3.2 Desain Penelitian | 40 |
| 3.3 Partisipan dan Tempat Penelitian | 42 |
| 3.4 Pengumpulan Data..... | 45 |

| | |
|---|-----|
| 3.4.1 Pengembangan Instrumen..... | 45 |
| 3.4.2 Prosedur Pengumpulan Data..... | 50 |
| 3.5 Analisis Data..... | 53 |
| 3.6 Isu Etik..... | 58 |
| BAB IV TEMUAN DAN PEMBAHASAN | 59 |
| 4.1 Kedalaman dan Keluasan Konten Biologi..... | 59 |
| 4.1.1 Konten Evolusi..... | 59 |
| 4.1.1.1 Kedalaman dan Keluasan Konten Evolusi Menurut Ilmuwan, Pendidik, dan Guru..... | 60 |
| 4.1.1.2 Penjenjangan Bidang Evolusi untuk Sekolah Dasar dan Menengah..... | 69 |
| 4.1.2 Konten Ekologi..... | 81 |
| 4.1.2.1 Kedalaman dan Keluasan Konten Ekologi Menurut Ilmuwan, Pendidik, dan Guru..... | 83 |
| 4.1.2.2 Penjenjangan Bidang Ekologi untuk Sekolah Dasar dan Menengah..... | 98 |
| 4.1.3 Konten Genetika..... | 107 |
| 4.1.3.1 Kedalaman dan Keluasan Konten Genetika Menurut Ilmuwan, Pendidik, dan Guru..... | 111 |
| 4.1.3.2 Penjenjangan Bidang Genetika untuk Sekolah Dasar dan Menengah | 120 |
| 4.1.4 Konten Fisiologi..... | 130 |
| 4.1.4.1 Kedalaman dan Keluasan Konten Fisiologi Menurut Ilmuwan, Pendidik, dan Guru..... | 132 |
| 4.1.4.2 Penjenjangan Bidang Fisiologi untuk Sekolah Dasar dan Menengah..... | 144 |
| 4.1.5 Konten Biologi Sel..... | 156 |
| 4.1.5.1 Kedalaman dan Keluasan Konten Biologi Sel Menurut Ilmuwan, Pendidik, dan Guru..... | 158 |

| | |
|---|------------|
| 4.1.5.2 Penjenjangan Bidang Biologi Sel untuk Sekolah Dasar dan Menengah..... | 170 183 |
| 4.1.6 Konten Biosistemika dan Taksonomi..... | |
| 4.1.6.1 Kedalaman dan Keluasan Konten Biosistemika dan Taksonomi Menurut Ilmuwan, Pendidik, dan Guru..... | 186 |
| 4.1.6.2 Penjenjangan Bidang Biosistemika dan Taksonomi untuk Sekolah Dasar dan Menengah..... | 199 |
| 4.2 Pandangan Ilmuwan, Pendidik, dan Guru tentang Kedalaman dan Keluasan Konten Biologi..... | 212 |
| BAB V SIMPULAN, IMPLIKASI, DAN REKOMENDASI | 237 |
| 5.1 Simpulan | 237 |
| 5.2 Implikasi | 238 |
| 5.3 Rekomendasi | 239 |
| DAFTAR PUSTAKA | 241 |
| LAMPIRAN | 260 |

DAFTAR PUSTAKA

- Adi Putra, M. J., Widodo, A., & Sopandi, W. (2017). Science Teachers' Pedagogical Content Knowledge and Integrated Approach. *Journal of Physics: Conference Series*, 895(1). <https://doi.org/10.1088/1742-6596/895/1/012144>
- Akçay, S. (2016). Prospective elementary science teachers' understanding of photosynthesis and cellular respiration in the context of multiple biological levels as nested systems. *Journal of Biological Education*, 9266(July). <https://doi.org/10.1080/00219266.2016.1170067>
- Akyol, G., Tekkaya, C., & Sungur, S. (2010). The contribution of understandings of evolutionary theory and nature of science to pre-service science teacher's acceptance of evolutionary theory. *Procedia - Social and Behavioral Sciences*, 9, 1889–1893. <https://doi.org/10.1016/j.sbspro.2010.12.419>
- Allen, D., & Tanner, K. (2003). *Approaches to Cell Biology Teaching: Learning Content in Context — Problem-Based Learning*. 2, 73–81. <https://doi.org/10.1187/cbe.03-04-0019>
- Alters, B. J., & Nelson, C. E. (2002). Perspective: Teaching evolution in higher education. *Evolution*, 56(10), 1891–1901. <https://doi.org/10.1111/j.0014-3820.2002.tb00115.x>
- Amrulloh, A., & Ardhi, M. W. (2017). Identifikasi kemampuan metakognisi pada mata kuliah biologi sel mahasiswa program studi pendidikan biologi. *Prosiding Seminar Nasional SIMBIOSIS II, September*, 104–113. <http://prosiding.unipma.ac.id/index.php/simbiosis/article/view/325>
- Anggari, A. S., Afikri, Wulan, D. R., Puspitawati, N., Khasanah, L. M., & Hendriyeti, S. (2017). *Peduli Terhadap Makhluk Hidup*. Pusat Kurikulum dan Perbukuan.
- Anif, S., Utama, Prayitno, H. J., & Idrus, N. B. M. (2019). Effectiveness of pedagogical competence: A development model through association of biology teachers' forum. *Jurnal Pendidikan IPA Indonesia*, 8(1), 22–31. <https://doi.org/10.15294/jpii.v8i1.17176>
- Annetta, L. A., Minogue, J., Holmes, S. Y., & Cheng, M. (2009). Computers & Education Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education*, 53(1), 74–85. <https://doi.org/10.1016/j.compedu.2008.12.020>

Susanti Wulandari, 2022

Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru

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

- Ansari, D., Coch, D., & De Smedt, B. (2011). Connecting education and cognitive neuroscience: Where will the journey take us? *Educational Philosophy and Theory*, 43(1), 37–42. <https://doi.org/10.1111/j.1469-5812.2010.00705.x>
- Anshori, M., & Martono, D. (2009). *Biologi untuk Siswa Sekolah Menengah Atas (SMA) - Madrasah Aliah (MA) Kelas X*. Pusat Perbukuan Departemen Pendidikan Nasional. <http://www.sinauer.com/media/wysiwyg/tocs/PlantPhysiology5.pdf>
- Anwar, Y., Rustaman, N. Y., & Widodo, A. (2014). *Hypothetical Model to Developing Pedagogical Content Knowledge (PCK) Prospective Biology Teachers in Consecutive Approach*. 3(12), 138–143.
- Araz, G., & Sungur, S. (2007). *Problem-based Learning Effectiveness of Problem-Based Learning on Academic Performance in Genetics*. 35(6), 448–451. <https://doi.org/10.1002/bambd.97>
- Arnold, G. (2012). Enhancing college students' environmental sensibilities through online nature journaling. *Environmental Education Research*, 18(1), 133–150. <https://doi.org/10.1080/13504622.2011.589000>
- Asghar, A., Wiles, J., & Alters, B. (2007). Canadian Pre-Service Elementary Teachers' Conceptions of Biological Evolution and Evolution Education. *McGill Journal of Education*, 42(2), 189–209.
- Astuti, I. M. J., & Susilawati, F. (2017). *Merawat Hewan dan Tumbuhan Buku Tematik Teroadu Kurikulum 2013*. Pusat Kurikulum dan Perbukuan.
- Augutter, P. S., & Wheatley, D. N. (2008). Thinking about Life: The History and Philosophy of Biology and Other Sciences. In *Springer*. Springer.
- Awaludin, R. B., Widodo, A., & Purwianingsih, W. (2015). Perbandingan Kemampuan Penyusunan Struktur Materi Subjek Fotosintesis Guru Biologi Pemula dan Guru Berpengalaman. *Prosiding Simposium Nasional Inovasi Dan Pembelajaran Sains (SNIPS)*, (Snips), 509–512.
- Ayu, G. M. (2016). *Perbandingan Keluasan, Kedalaman, dan Kemutakhiran Isi Buku Biologi SMA Indonesia dengan Beberapa Negara Lain pada Topik Genetika*. Universitas Negeri Medan.
- Bahar, M., Johnstone, A. H., Sutcliffe, R. G., & Johnstone, A. H. (2010). *Investigation of students ' cognitive structure in elementary genetics through word association tests*. August 2012, 37–41.
- Barker, S., & Slingsby, D. (1998). International Journal of Science From nature table to niche : curriculum progression in ecological concepts. *International Journal of Science Education*, 20(February 2015), 479–486. <https://doi.org/10.1080/0950069980200407>
- Bates, G. D. (1996). *I Don ' T Believe in Change*. June, 20–24.

- Baxter, G. P., & Shavelson†, R. J. (1994). Science performance assessments: benchmarks and surrogates. *International Journal of Educational Research*, 21(3), 279–298. [https://doi.org/10.1016/S0883-0355\(06\)80020-0](https://doi.org/10.1016/S0883-0355(06)80020-0)
- Belbase, S. (2011). *Philosophical foundations for curriculum decision: A reflective analysis*. 1–20. <https://files.eric.ed.gov/fulltext/ED524740.pdf>
- Bell, C. R. (1965). Molecular Plant Taxonomy. In *The American Biology Teacher* (Vol. 27, Issue 2). <https://doi.org/10.2307/4440844>
- Berkman, M. B., & Plutzer, E. (2011). Defeating creationism in the courtroom, but not in the classroom. *Science*, 331(6016), 404–405. <https://doi.org/10.1126/science.1198902>
- Bilton, D. T. (2014). Whats in a name? What have taxonomy and systematics ever done for us? *Journal of Biological Education*, 48(3), 116–118. <https://doi.org/10.1080/00219266.2014.926653>
- Brown, M. H., & Schwartz, R. (2009). Connecting Photosynthesis and Cellular Respiration : Preservice Teachers ' Conceptions Department of Biological Sciences , Mallinson Institute for Science Education ,. *Journal of R*, 46(7), 791–812. <https://doi.org/10.1002/tea.20287>
- Brown, P. J. P. (2020). *Process-oriented guided-inquiry learning in an introductory anatomy and physiology course with a diverse student population*. 19, 150–155. <https://doi.org/10.1152/advan.00055.2010>.
- Bruer, J. T. (1997). Education and the brain: A bridge too far. *Educational Researcher*, 26(4), 4–16. <https://doi.org/10.3102/0013189X026008004>
- Bruner, J. S. (1964). The course of cognitive growth. *American Psychologist*, 19(1), 1–15. <https://doi.org/10.1037/h0044160>
- Bruner, J. S. (1966). *Toward a Theory of Instruction*. The Belknap Press of 1996 Harvard University Press.
- Bruner, J. S. (1999). The Process of Education - A Landmark in Educational Theory. In *Cambridge, London: Harvard University Press* (Vol. 25). Harvard University Press. [http://beceneslp.edu.mx/PLANES2012/3er_Sem/Ingl?sA1/Material/2/F\)bruner_discovery_learning.pdf](http://beceneslp.edu.mx/PLANES2012/3er_Sem/Ingl?sA1/Material/2/F)bruner_discovery_learning.pdf)
- CAMPBELL, R. (2007). *Campbell, Reece - BCampbell, Reece - Biology, 8th Edition -Benjamin-Cummings Pub Co (2007). (n.d.).iology, 8th Edition - Benjamin-Cummings Pub Co (2007) (p. 1465)*.
- Campo, D., & Garcia-Vazquez, E. (2008). Inquiry-based learning of molecular phylogenetics. *Journal of Biological Education*, 43(1), 15–20. <https://doi.org/10.1080/00219266.2008.9656144>
- Capra, F. (1996). THE WEB OF LIFE. In *Web of Life*. Anchor.

- Carlan, F. D. A., Maria, L., Sepel, N., Lucio, E., & Loreto, S. (2014). *Teaching Cell Biology in Primary Schools. 2014.*
- Carrier, S. J. (2009). The Effects of Outdoor Science Lessons with Elementary School Students on Preservice Teachers' Self-Efficacy. *Journal of Elementary Science Education, 21*(2), 35–48.
- Cavallo, A. M. L., & McCau, D. (2008). Seeing may not mean believing: Examining students' understandings and beliefs in evolution. *American Biology Teacher, 70*(9), 522–530. <https://doi.org/10.1662/0002-7685-70.9.522>
- Chanet, B., & Lusignan, F. (2008). Teaching Evolution in Primary Schools: An Example in French Classrooms. *Evolution: Education and Outreach, 2*(1), 136–140. <https://doi.org/10.1007/s12052-008-0095-y>
- Clough, E. E., Wood-robinson, C., & Clough, E. E. (2016). *Children's understanding of inheritance Children's understanding of inheritance. 9266*(February). <https://doi.org/10.1080/00219266.1985.9654757>
- Cochran, K. F., DeRuiter, J. ., & King, R. . (1993). Pedagogical content knowing: an integrative model for teacher preparation. *Journal of Teacher Education, 44*(4), 263–272.
- Cohen, R., & Yarden, A. (2009). Experienced junior-high-school teachers' PCK in light of a curriculum change: "The cell is to be studied longitudinally." *Research in Science Education, 39*(1), 131–155. <https://doi.org/10.1007/s11165-008-9088-7>
- Colley, K. E. (2010). Science Activities: Classroom Projects and Curriculum Ideas. *Science Activities, 43*(1), 26–33. <https://doi.org/10.3200/SATS.43.1.26-33>
- Committee on a New Biology for the 21st Century: Ensuring the United States Leads the Coming Biology Revolution, N. R. C. (2009). *A New Biology for the 21st Century*. The National Academies Press. <https://doi.org/10.17226/12764>
- Cooper, K. M., Krieg, A., & Brownell, S. E. (2020). *Who perceives they are smarter? Exploring the influence of student characteristics on student academic self-concept in physiology. 40, 200–208.* <https://doi.org/10.1152/advan.00085.2017>
- Cortright, R. N., Collins, H. L., Rodenbaugh, D. W., & DiCarlo, S. E. (2003). Student retention of course content is improved by collaborative-group testing. *American Journal of Physiology - Advances in Physiology Education, 27*(1–4), 102–108. <https://doi.org/10.1152/advan.00041.2002>
- Creswell, J. . (2012). *Educational Research Planning, Conducting and Evaluating Quantitative and Qualitative Research* (M. Buchholtz (ed.); Fourth Ed.). Pearson Education Inc.

- Crowe, A., Dirks, C., & Wenderoth, M. P. (2008). Biology in bloom: Implementing Bloom's taxonomy to enhance student learning in biology. *CBE Life Sciences Education*, 7(4), 368–381. <https://doi.org/10.1187/cbe.08-05-0024>
- Dagher, Z. R., & Boujaoude, S. (1997). Scientific Views and Religious Beliefs of College Students: The Case of Biological Evolution. *Journal of Research in Science Teaching*, 34(5), 429–445. [https://doi.org/10.1002/\(SICI\)1098-2736\(199705\)34:5<429::AID-TEA2>3.0.CO;2-S](https://doi.org/10.1002/(SICI)1098-2736(199705)34:5<429::AID-TEA2>3.0.CO;2-S)
- de Carvalho, Í. N., El-Hani, C. N., & Nunes-Neto, N. (2020). How Should We Select Conceptual Content for Biology High School Curricula? *Science and Education*, 29(3), 513–547. <https://doi.org/10.1007/s11191-020-00115-9>
- Dehaene, S., Dehaene-Lambertz, G., & Cohen, L. (1998). Abstract representations of numbers in the animal and human brain. *Trends in Neurosciences*, 21(8), 355–361. [https://doi.org/10.1016/S0166-2236\(98\)01263-6](https://doi.org/10.1016/S0166-2236(98)01263-6)
- Destiansari, E., Widodo, A., & Purwianingsih, W. (2017). Teachers' ability to integrated reasoning and student wellbeing in pedagogical content knowledge. *Advances in Social Science, Education and Humanities Research (ASSEHR)*, 57(ICMSEd 2016), 159–163. <https://doi.org/10.2991/icmsed-16.2017.35>
- Dewi, I. S., Sunariyati, S., & Neneng, L. (2014). Analisis Kendala Pelaksanaan Praktikum Biologi di SMA Negeri se-Kota Palangka Raya. *Journal of the Mining Institute of Japan*, 2(1), 13–26. https://doi.org/10.2473/shigentosozai1953.83.947_421
- Diana, R., & Widodo, A. (2017). *Perbandingan Penalaran Ilmiah pada Sekolah yang Menggunakan KTSP dengan Kurikulum 2013*. Universitas Pendidikan Indonesia.
- DiCarlo, S. E. (2009). Too much content, not enough thinking, and too little FUN! *American Journal of Physiology - Advances in Physiology Education*, 33(4), 257–264. <https://doi.org/10.1152/advan.00075.2009>
- Dikmenli, M. (2010). Misconceptions of cell division held by student teachers in biology: A drawing analysis. *Scientific Research and Essays*, 5(2), 235–247. <https://doi.org/10.5897/SRE.9000654>
- Dogru-atay, P., & Tekkaya, C. (2010). *The Journal of Experimental Promoting Students' Learning in Genetics With the Learning Cycle Promoting Students' Learning in Genetics With the Learning Cycle. June 2013*, 37–41.
- Donatirin, S., Hananta, B., & Mahmudin, M. (2017). *Panduan Pembelajaran yang Menyenangkan Melalui Sainifik Pada Anak Usia 3-4 Tahun*. Kementerian Pendidikan dan Kebudayaan.
- Donnelly, L. A., Kazempour, M., & Amirshokoohi, A. (2009). High school students' perceptions of evolution instruction: Acceptance and evolution learning experiences. *Research in Science Education*, 39(5), 643–660.

<https://doi.org/10.1007/s11165-008-9097-6>

- Duit, R., Treagust, D. F., & Widodo, A. (2008). Teaching science for conceptual change: Theory and practice. *International Handbook of Research on Conceptual Change*, 487–503. <https://doi.org/10.4324/9780203154472>
- Duncan, R. G., Freidenreich, H. B., Chinn, C. A., & Bausch, A. (2011). *Promoting Middle School Students' Understandings of Molecular Genetics*. 147–167. <https://doi.org/10.1007/s11165-009-9150-0>
- Duncan, R. G., & Reiser, B. J. (2007). *Reasoning Across Ontologically Distinct Levels: Students' Understandings of Molecular Genetics*. 44(7), 938–959. <https://doi.org/10.1002/tea>
- Duncan, R. G., Rogat, A. D., & Yarden, A. (2009). *A Learning Progression for Deepening Students' Understandings of Modern Genetics Across the 5th – 10th Grades*. 46(6), 655–674. <https://doi.org/10.1002/tea.20312>
- Duncan, R. G., & Tseng, K. A. N. N. (2010). *Designing Project-Based Instruction to Foster Generative and Mechanistic Understandings*. 21–56. <https://doi.org/10.1002/sce.20407>
- Dunk, R. D. P., Petto, A. J., Wiles, J. R., & Campbell, B. C. (2017). A multifactorial analysis of acceptance of evolution. *Evolution: Education and Outreach*, 10(1). <https://doi.org/10.1186/s12052-017-0068-0>
- Eshach, H., & Fried, M. N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology*, 14(3), 315–336. <https://doi.org/10.1007/s10956-005-7198-9>
- Evi Apriana, Achmad Munandar, Nuryani Y Rustaman, & Hertien Koosbandiah Surtikanti. (2020). Pengembangan Program Perkuliahan Biologi Konservasi Dengan Pendekatan Kontekstual Berbasis Kearifan Lokal Aceh. *Visipena Journal*, 11(1), 1–15. <https://doi.org/10.46244/visipena.v11i1.1086>
- Fail, J. (2008). A No-Holds-Barred Evolution Curriculum for Elementary and Junior High School Students. *Evolution: Education and Outreach*, 1(1), 56–64. <https://doi.org/10.1007/s12052-007-0018-3>
- Fatimah, N. (2019). *Pengaruh Model Pembelajaran Problem Based Learning Berbantu Bagan Dikotomi Konsep Terhadap Berpikir Kritis Ditinjau dari Self Esteem Peserta Didik Kelas X di SMA Negeri 15 Bandar Lampung*.
- Fernández-Balboa, J. M., & Stiehl, J. (1995). The generic nature of pedagogical content knowledge among college professors. *Teaching and Teacher Education*, 11(3), 293–306. [https://doi.org/10.1016/0742-051X\(94\)00030-A](https://doi.org/10.1016/0742-051X(94)00030-A)
- Fischer, J., Jansen, T., Möller, J., & Harms, U. (2021). Measuring biology trainee teachers' professional knowledge about evolution—introducing the Student Inventory. *Evolution: Education and Outreach*, 14(1), 1–16. <https://doi.org/10.1186/s12052-021-00144-0>

Susanti Wulandari, 2022

Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Friedrichsen, P. M. (2001). Moving from Hands-On to Inquiry-Based : for Biology Course Prospective Elementary Teachers Format of the Hands-On Biology Course. *The American Biology Teacher*, 63(8), 562–568.
- Fukuyama, M. (2018). Society 5.0: Aiming for a New Human-centered Society. *Japan SPOTLIGHT*, 27(August), 47–50. <https://www.jef.or.jp/journal/>
- Fyrenius, A., Sile, C., Wirell, S., & Fyrenius, A. (2007). *Students ' conceptions of underlying principles in medical physiology : an interview study of medical students ' understanding in a PBL curriculum*. 17, 364–369. <https://doi.org/10.1152/advan.00108.2006>.
- Geake, J. (2004). Cognitive neuroscience and education : two-way traffic or one-way street? *Westminster Studies in Education*, 27(1), 87–98. <https://doi.org/10.1080/0140672040270107>
- Gess-newsome, J., & Lederman, N. . (1986). Pedagogical Content Knowledge: An introduction and orientation. *PCK and Science Education*, 3–17.
- Gilbert, J. K., Osborne, R. J., & Fensham, P. J. (1982). *Children ' s Science and Its Consequences for Teaching*. 66(4), 623–633.
- Golding, C. (2009). *Integrating the disciplines: Successful interdisciplinary subjects* (pp. 1–27). http://www.cshe.unimelb.edu.au/resources_teach/curriculum_design/docs/Int_erdisc_Guide.pdf
- Gonzales, H. L., Palencia, A. P., Uman, L. A., Galindo, L., & M, L. A. V. (2008). Mediated learning experience and concept maps: a pedagogical tool for achieving meaningful learning in medical physiology students. *Adv Physiol Educ*, 32, 312–316. <https://doi.org/10.1152/advan.00021.2007>.
- Goswami, U. (2004). Annual review Neuroscience and education. *British Journal of Educational Psychology*, 74, 1–14.
- Goswami, U. (2008). Principles of Learning , Implications for Teaching: A Cognitive Neuroscience Perspective. *Journal of Philosophy of Education*, 42(3), 381–399.
- Gultom, H. S. B. (2011). *Identifikasi Miskonsepsi Guru dan Siswa tentang Materi Sel di SMA Negeri Se-Kabupaten Deliserdang*. Universitas Negeri Medan.
- Hadiati, D., & Nasution, M. Y. (2016). Perbedaan Hasil Belajar yang Diajarkan dengan Model Pembelajaran Problem Based Learning (PBL) dan Model Pembelajaran Inkuiri pada Materi Sel di SMA Negeri 16 Medan T.P. 2015/2016. *Jurnal Pelita Indonesia*, 4(1), 82–90.
- Harmonika, L. (2016). *Perbandingan Kelengkapan, Keluasan, dan Kedalaman Isi Buku Teks Biologi SMA Indonesia dengan Buku Terbitan Cambridge pada Topik Biodiversitas*. Universitas Negeri Medan.

- Harris, D. M., Bellew, C., Cheng, Z. J., Cendán, J. C., & Kibble, J. D. (2014). High-fidelity patient simulators to expose undergraduate students to the clinical relevance of physiology concepts. *Adv Physiol Educ*, *38*, 372–375. <https://doi.org/10.1152/advan.00063.2014>
- Hasyim, W., Suwono, H., & Susilo, H. (2018). *Three-tier Test to Identify Students' Misconception of Human Reproduction System*. *6*(2), 48–54.
- Hebert, P. D. N., & Gregory, T. R. (2005). The promise of DNA barcoding for taxonomy. *Systematic Biology*, *54*(5), 852–859. <https://doi.org/10.1080/10635150500354886>
- Herlanti, Y. (2008). Penggunaan Metoda Metafora dalam Proses Apresispsi Mata Kuliah Biologi Sel. *Edusains*, *1*(2), 156–166.
- Hermann, R. S. (2011). Breaking the Cycle of Continued Evolution Education Controversy: On the Need to Strengthen Elementary Level Teaching of Evolution. *Evolution: Education and Outreach*, *4*(2), 267–274. <https://doi.org/10.1007/s12052-011-0325-6>
- Hermann, R. S. (2016). Elementary education majors' views on evolution: A comparison of undergraduate majors understanding of natural selection and acceptance of evolution. *Electronic Journal of Science Education*, *20*(6), 21–44.
- Horwitz, P., McIntyre, C. A., Lord, T. L., O'Dwyer, L. M., & Staudt, C. (2013). Teaching “Evolution readiness” to fourth graders. *Evolution: Education and Outreach*, *6*(1), 1–12. <https://doi.org/10.1186/1936-6434-6-21>
- Husnita, L., Wardhani, S., & Nawawi, S. (2019). Analisis Tingkat Keterampilan Berpikir Kritis Siswa pada Materi Sel di SMA Negeri Palembang. *Bioilmi*, *5*(2), 114–126.
- Undang-Undang Republik Indonesia Nomor 14 Tahun 2005 tentang Guru dan Dosen, 1 (2005).
- Jandrić, P., Knox, J., Besley, T., Ryberg, T., Suoranta, J., & Hayes, S. (2018). Postdigital science and education. *Educational Philosophy and Theory*, *50*(10), 893–899. <https://doi.org/10.1080/00131857.2018.1454000>
- Jeffery, K. R., & Roach, L. E. (1994). A study of the presence of evolutionary protoconcepts in pre-high school textbooks. *Journal of Research in Science Teaching*, *31*(5), 507–518. <https://doi.org/10.1002/tea.3660310506>
- Jensen, M., Mattheis, A., & Loyle, A. (2020). Offering an anatomy and physiology course through a high school-university partnership: the Minnesota model. *Adv Physiol Educ*, *37*, 157–164. <https://doi.org/10.1152/advan.00147.2012>
- Johnson, A. P. (2016). Bruner'S Learning Theory. In *Essential Learning Theories and Their Applications* (pp. 1–5).

- Jones, M., & Jones, G. (2014). *Cambridge IGCSE Biology Coursebook* (Third). Cambridge University Press.
- Jordan, R. C., Vaughan, J., & Berkowitz, A. R. (2009). *What should every citizen know about ecology? November*. <https://doi.org/10.1890/070113>
- Kampourakis, K., & Zogza, V. (2008). Students' intuitive explanations of the causes of homologies and adaptations. *Science and Education*, 17(1), 27–47. <https://doi.org/10.1007/s11191-007-9075-9>
- Kasih, A. P., & Nurcahyo, H. (2020). Pengembangan Model Pembelajaran Adel (Active and Delightful Learning) pada Materi Organel Sel Kelas VII SMA. *Edusains*, 12(1), 135–144.
- Permendikbud No. 24 tahun 2016 tentang Kompetensi Inti dan Kompetensi Dasar Pelajaran pada Kurikulum 2013 pada Pendidikan Dasar dan Pendidikan Menengah, 2025 JDIH Kemendikbud 1 (2018).
- Peraturan Pemerintah Republik Indonesia Nomor 19 Tahun 2005, 1 (2005). http://www.mantenimientoplanificado.com/articulos_rcm_archivos/ariel_ZYLBERBERG/RCM_Scorecard_overview.pdf%0Ahttp://dx.doi.org/10.1016/j.jsames.2011.03.003%0Ahttps://doi.org/10.1016/j.gr.2017.08.001%0Ahttp://dx.doi.org/10.1016/j.precamres.2014.12.018%0Aht
- Kerr, S., Muller, D., Mckinon, W., & Inerney, P. M. (2016). *An online formative assessment tool to prepare students for summative assessment in physiology*. 8(1), 72–76. <https://doi.org/10.7196/AJHPE.2016.v8i1.581>
- Klegeris, A., & Hurren, H. (2011). Impact of problem-based learning in a large classroom setting: Student perception and problem-solving skills. *American Journal of Physiology - Advances in Physiology Education*, 35(4), 408–415. <https://doi.org/10.1152/advan.00046.2011>
- Konsorsium Biologi Indonesia (KOBI). (2015). *Rumusan Naskah Akademik Standar Nasional Berbasis KKNI*.
- Kuo, F. E., & Faber Taylor, A. (2004). A potential natural treatment for attention-deficit/hyperactivity disorder: Evidence from a national study. *American Journal of Public Health*, 94(9), 1580–1586. <https://doi.org/10.2105/AJPH.94.9.1580>
- Kusumawardani, W., Muzzazinah, & Ramli, M. (2019). Plant taxonomy learning and research: A systematics review. *AIP Conference Proceedings*, 2194(December). <https://doi.org/10.1063/1.5139783>
- Lewis, J., Leach, J., & Wood-robinson, C. (2010). *Chromosomes : the missing link — young people ' s*. June 2015, 37–41. <https://doi.org/10.1080/00219266.2000.9655717>
- Lhoussaine, M., Alami, A., Agorram, B., & Zaki, M. (2020). Research in Didactics of Natural Sciences and Pedagogical Innovation for Scientific Education. Susanti Wulandari, 2022
Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
 Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

Plant Taxonomy Learning in Moroccan University Level: Student's Motivation and Alternative Conceptions, DOI: 10.97(April), 76–95.
<https://doi.org/10.9734/bpi/mono/978-93-89816-74-7>

Luciana, N. A. (2017). Analisis Miskonsepsi Siswa dengan Menggunakan Bagan Dikotomi Konsep pada Mata Pelajaran IPA Biologi Materi Fotosintesis Siswa Kelas VIII SMP Negeri 26 Bandar Lampung. In *Fakultas Tarbiyah dan Keguruan Institut Agama Islam Negeri Raden Intan Lampung: Vol.*

Lujan, H. L., & DiCarlo, S. E. (2006). Too much teaching, not enough learning: What is the solution? *American Journal of Physiology - Advances in Physiology Education*, 30(1), 17–22.
<https://doi.org/10.1152/advan.00061.2005>

Magntorn, O., & Helldén, G. (2007). Reading nature from a “bottom-up” perspective. *Journal of Biological Education*, 41(2), 68–75.
<https://doi.org/10.1080/00219266.2007.9656065>

Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S. J., & Frith, C. D. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proceedings of the National Academy of Sciences of the United States of America*, 97(8), 4398–4403.
<https://doi.org/10.1073/pnas.070039597>

Marbach-Ad, G., & Stavy, R. (2010). *Students' cellular and molecular explanations of genetic phenomena. October 2012*, 37–41.

Marks, R. (1990). Pedagogical content knowledge: from a mathematical case to a modified conception. *Journal of Teacher Education*, 41(3), 3–11.
<https://doi.org/10.1177/002248719004100302>

Martins-Loução, M. A., Gaio-Oliveira, G., Barata, R., & Carvalho, N. (2020). Inquiry-based science learning in the context of a continuing professional development programme for biology teachers. *Journal of Biological Education*, 54(5), 497–513. <https://doi.org/10.1080/00219266.2019.1609566>

Mcfarland, X. J. L., & Michael, X. J. A. (2020). *P-MIG Special Collection Reflections on core concepts for undergraduate physiology programs. 2*, 626–631. <https://doi.org/10.1152/advan.00188.2019>

McKeachie, W. J., Lin, Y.-G., & Strayer, J. (2002). Beliefs: Creationist vs . Evolutionary Effects on Biology Learning. *The American Biology Teacher*, 64(3), 189–192.

McVaugh, N. K., Birchfield, J., Lucero, M. M., & Petrosino, A. J. (2011). Evolution Education: Seeing the Forest for the Trees and Focusing Our Efforts on the Teaching of Evolution. *Evolution: Education and Outreach*, 4(2), 286–292.
<https://doi.org/10.1007/s12052-010-0297-y>

Salinan Lampiran Peraturan Menteri Pendidikan Nasional Nomor 16 Tahun 2007,

Susanti Wulandari, 2022

Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru

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

- 1 (2007). [http://digilib.unila.ac.id/4949/15/BAB II.pdf](http://digilib.unila.ac.id/4949/15/BAB%20II.pdf)
- Michael, J. (2017). What Are the Core Concepts of Physiology? *The American Physiological Society*, 27–36. <https://doi.org/10.1007/978-1-4939-6909-8>
- Michael, Joel. (2007). *What makes physiology hard for students to learn? Results of a faculty survey*. 60612, 34–40. <https://doi.org/10.1152/advan.00057.2006>.
- Michael, Joel, Modell, H., Mcfarland, J., & Cliff, W. (2009). The “ core principles ” of physiology : what should students understand ? *Adv Physiol Educ*, 33, 10–16. <https://doi.org/10.1152/advan.90139.2008>.
- Mikropoulos, T. A., Katsikis, A., Nikolou, E., & Tsakalis, P. (2003). Virtual environments in biology teaching Virtual environments in. *Journal of Biological Education*, 37(4), 176–181. <https://doi.org/10.1080/00219266.2003.9655879>
- Modell, H. I. (2018). *HOW TO HELP STUDENTS*. 23(1), 101–107.
- Moore, R. Brooks, D.C., & Cotner, S. (2011). RESEARCH ON L E A R N I N G The Relation of High School Biology Courses & Students ’ Religious Beliefs to College Students ’ Knowledge of Evolution Analysis & Model. *Research on Learning*, 73(4), 222–226. <https://doi.org/10.1525/abt.2011.73.4.7>
- Morrar, R., Arman, H., & Saeed, M. (2017). The fourth industrial revolution (Industry 4,0): A social innovation perspective. *Technology Innovation Management Review*, 7(11), 12–20. <https://doi.org/10.22215/TIMREVIEW/1396>
- Morrell, P. D., & Carroll, J. B. (2003). An Extended Examination of Preservice Elementary Teachers’ Science Teaching Self-Efficacy. *School Science and Mathematics*, 103(5), 246–251. <https://doi.org/10.1111/j.1949-8594.2003.tb18205.x>
- Mulyani, S. S. (2013). Analisis Kedalaman dan Keluasan Materi pada Buku Teks Biologi SMP dan SMA Mengenai Konsep Sistem Pencernaan Makanan. In *Skripsi*. Universitas Pendidikan Indonesia.
- Muspikawijaya, Iswari, R. S., & Marianti, A. (2017). Analisis kesulitan peserta didik SMA/MA Kabupaten Luwu Timur dalam memahami konsep pada materi metabolisme sel. *Journal of Innovative Science Education*, 6(2), 252–263.
- Nadelson, L., Culp, R., Bunn, S., Burkhart, R., Shetlar, R., Nixon, K., & Waldron, J. (2008). Teaching Evolution Concepts to Early Elementary School Students. *Evolution: Education and Outreach*, 2(3), 458–473. <https://doi.org/10.1007/s12052-009-0148-x>
- National Research Council. (2011). Framework for K-12 Science Education : Practices, Crosscutting Concepts, and Core Ideas A Framework for K-12 Science Education : Practices, Crosscutting Concepts, and Core Ideas. In Susanti Wulandari, 2022 *Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru* Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

National Academies Press.

- National Science Teachers Association. (2003). *Standards for Science Teacher Preparation: Vol. (Issue)*. Department of Teaching, Learning and Teacher Education.
- Naumescu, A. (2008). Science Teacher Competencies in a Knowledge Based Society. *Acta Didactica Napocensia*, 1(1), 25–31.
- Nehm, R. H., & Reilly, L. (2007). Biology majors' knowledge and misconceptions of natural selection. *BioScience*, 57(3), 263–272. <https://doi.org/10.1641/B570311>
- Nilsson, P., & Loughran, J. (2012). Exploring the Development of Pre-Service Science Elementary Teachers' Pedagogical Content Knowledge. *Journal of Science Teacher Education*, 23(7), 699–721. <https://doi.org/10.1007/s10972-011-9239-y>
- Noble, H., & Mitchell, G. (2016). What is grounded theory? *Evidence-Based Nursing*, 19(2), 34–35. <https://doi.org/10.1136/eb-2016-102306>
- O'Malley, M. A., & Dupré, J. (2007). Size doesn't matter: towards a more inclusive philosophy of biology. *Biology and Philosophy*, 22(2), 155–191. <https://doi.org/10.1007/s10539-006-9031-0>
- Oktaviani, F., & Hidayat, T. (2015). Profil Keterampilan Berkomunikasi Siswa Sma Menggunakan Metode Fenetik Dalam Pembelajaran Klasifikasi Arthropoda. *Jurnal Pengajaran Matematika Dan Ilmu Pengetahuan Alam*, 15(1), 13. <https://doi.org/10.18269/jpmipa.v15i1.288>
- Oliver, C. D. (2003). Sustainable forestry: What is it? How do we achieve it? *Journal of Forestry*, 101(5), 8–17. <https://doi.org/10.1093/jof/101.5.8>
- Orozco, J. ., & Yangco, R. . (2016). Problem-based learning: effects on critical and creative thinking skills in Biology. *Asian Journal of Biology Education*, 9(November), 1–11.
- Palmer, D. H. (2006). Sources of self-efficacy in a science methods course for primary teacher education students. *Research in Science Education*, 36(4), 337–353. <https://doi.org/10.1007/s11165-005-9007-0>
- Paschal, C. B. (2020). *FORMATIVE ASSESSMENT IN PHYSIOLOGY TEACHING USING A WIRELESS CLASSROOM COMMUNICATION SYSTEM*. 26(4), 299–308.
- Patel, K., & Keyur. (2016). Internet of Things-IOT: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges. *Universidad Iberoamericana Ciudad de México, May*, 6123,6131. <http://www.opjstamnar.com/download/Worksheet/Day-110/IP-XI.pdf>
- Peklaj, C. (2015). Teacher competencies through the prism of educational research.

Susanti Wulandari, 2022

Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru

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

CEPS Journal - Center for Educational Policy Studies Journal, 5(3), 183–204.

- Pergams, O. R. W., & Zaradic, P. A. (2008). Evidence for a fundamental and pervasive shift away from nature-based recreation. *Proceedings of the National Academy of Sciences of the United States of America*, 105(7), 2295–2300. <https://doi.org/10.1073/pnas.0709893105>
- Phinney, D. G., & Sensebé, L. (2013). Mesenchymal stromal cells: Misconceptions and evolving concepts. *Cytotherapy*, 15(2), 140–145. <https://doi.org/10.1016/j.jcyt.2012.11.005>
- Pickett, S. T. ., & McDonnell, M. . (1989). Changing perspectives in community dynamics: A theory of successional forces. *Perspectives*, 4(8), 241–245.
- Pretty, J., Peacock, J., Sellens, M., & Griffin, M. (2005). The mental and physical health outcomes of green exercise. *International Journal of Environmental Health Research*, 15(5), 319–337. <https://doi.org/10.1080/09603120500155963>
- Price, S., & Hein, G. E. (2007). *International Journal of Science More than a field trip : science programmes for elementary school groups at museums More than a field trip : science programmes for elementary school groups at museums* *. June 2013, 37–41.
- Pritchard, A. (2020). Ways of Learning: Learning Theory and Learning Style in The Classroom. In *2009 Routledge*.
- Pugh, K. R., Mencl, W. E., Jenner, A. R., Katz, L., Frost, S. J., Lee, J. R., Shaywitz, S. E., & Shaywitz, B. A. (2001). Neurobiological studies of reading and reading disability. *Journal of Communication Disorders*, 34(6), 479–492. [https://doi.org/10.1016/S0021-9924\(01\)00060-0](https://doi.org/10.1016/S0021-9924(01)00060-0)
- Pujiriyanto. (2019). *MODUL 2 “Peran Guru Dalam Pembelajaran Abad 21.”* 168.
- Purnomo, Sudjino, Trijoko, & Hadisusanto, S. (2009). *Biologi Kelas XI untuk SMA dan MA* (W. . Omegawati, S. Lestari, & K. Ariyanti (eds.)). Pusat Perbukuan Dpartemen Pendidikan Nasional.
- Putra, M. J. A., Widodo, A., Sopandi, W., Purwianingsih, W., Mardiyah, A., Aminah, N., & Wahyuni, I. (2017). *Teacher Pedagogical Content Knowledge (PCK) and Students ’ Reasoning and Wellbeing Teacher Pedagogical Content Knowledge (PCK) and Students ’ Reasoning and Wellbeing*. <https://doi.org/10.1088/1742-6596/755/1/011001>
- Rahmadhani, F., Armen, A., Darussyamsu, R., Fadilah, M., & Putri, D. H. (2019). The Development of Biology Module Based on Emotional Spiritual Quotient in Evolution Topic for Senior High School. *Scientiae Educatia*, 8(2), 166. <https://doi.org/10.24235/sc.educatia.v8i2.2525>
- Rahman, T., Rustaman, N. Y., Sukmadinata, N. S., & Poedjiadi, A. (2006). Profil Kemampuan Generik Perencanaan Percobaan Calon Guru Hasil Pembelajaran Susanti Wulandari, 2022
Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Berbasis Kemampuan Generik pada Praktikum Fisiologi Tumbuhan. *Educare*, 4(1), 72–87.
- Randler, C. (2008). *Teaching Species Identification – A Prerequisite for Learning Biodiversity and Understanding Ecology*. 4(3), 223–231.
- Rochintaniawati, D., Widodo, A., Riandi, R., & Herlina, L. (2018). Pedagogical Content Knowledge Development of Science Prospective Teachers in Professional Practice Program. *Unnes Science Education Journal*, 7(2), 119–128. <https://doi.org/10.15294/usej.v7i2.23291>
- Rosenberg, A., & McShea, D. W. (2018). *Philosophy of biology: A Contemporary Introduction*. Routledge. <https://doi.org/10.1093/oso/9780190690649.003.0012>
- Rusmana, A. N., Aini, R. Q., Sya'bandari, Y., Ha, M., Shin, S., & Lee, J. K. (2019). Probing high school students' perceptions of the concept of species: a semantic network analysis approach. *Journal of Biological Education*, 00(00), 1–15. <https://doi.org/10.1080/00219266.2019.1707261>
- Rustaman, N Y. (2018). Integrasi Aspek Afektif-Kognitif melalui Pembelajaran Bioresources Berorientasi Local Wisdom dan Berpikir Sistem untuk Membekali Perilaku Konservasi melalui *Prosiding Biotik*, 1–11. <https://www.jurnal.ar-raniry.ac.id/index.php/PBiotik/article/view/2602>
- Rustaman, Nuryani Y. (1990). *Kemampuan Klasifikasi Logis Anak: Studi tentang Kemampuan Abstraksi dan Inferensi Anak Usia SD pada Kelompok Budaya Sunda*. Universitas Pendidikan Indonesia.
- Rusyana, A., & Rustaman, N. Y. (2011). Pengembangan Program Perkuliahan Zoologi Invertebrata (P3ZI) Berbasis Keterampilan Berpikir Kritis. *Bioedukasi*, 4(2), 1–12. <https://media.neliti.com/media/publications/61822-ID-pengembangan-program-perkuliahan-zoologi.pdf>
- Sánchez, E., & Craig, R. (2007). Strengthening teaching effectiveness through cooperative learning activities. *HortTechnology*, 17(2), 254–257. <https://doi.org/10.21273/horttech.17.2.254>
- Saputra, A. (2017). Persepsi Mahasiswa Calon Guru Biologi tentang Pembelajaran Materi Evolusi di SMA: Studi kasus mahasiswa pendidikan Biologi FKIP Universitas Sebelas Maret Surakarta. *Bioeducation Journal*, 1(1), 1–9. <http://ejournal.unp.ac.id/index.php/bioeducation/article/download/7085/5578>
- Sari, E. N. (2017). Pengaruh Model Pembelajaran Discovery Learning Dengan Mind Mapping Terhadap Hasil Belajar Siswa Pada Materi Sel Di SMA [Universitas Negeri Semarang]. In *USEJ: Unnes Science Education Journal* (Vol. 5, Issue 3). <https://doi.org/10.15294/usej.v5i3.13171>
- Sarkar, S., & Plutynski, A. (2008). *A Companion to the Philosophy of Biology*. In *Blackwell Publishing Ltd*. Blackwell Publishing.

- Schizas, D., Papatheodorou, E., & Stamou, G. (2021). Unraveling the holistic nature of ecosystems: biology teachers' conceptions of methodological choices regarding the study of ecosystems. *Environmental Education Research*, 27(1), 22–36. <https://doi.org/10.1080/13504622.2020.1819963>
- Schizas, D., Papatheodorou, E., Vezagkou, T., & Stamou, G. (2020). Unravelling the holistic nature of ecosystems: biology teachers' conceptions of ecosystem borders. *International Journal of Science Education*, 42(11), 1759–1778. <https://doi.org/10.1080/09500693.2020.1781287>
- Schwartz, M. S., Sadler, P. M., Sonnert, G., & Tai, R. H. (2008). *Depth Versus Breadth : How Content Coverage in High School Science Courses Relates to Later Coursework*. 798–826. <https://doi.org/10.1002/sce.20328>
- Seeger, R. J., & Cohen, R. S. (1974). Philosophical Foundations of Science. In *Philosophical Studies* (Proceeding, Vol. 11). D. Reidel Publishing Company. <https://doi.org/10.5840/philstudies19742345>
- Semsar, K., Brownell, S., Couch, B. A., Crowe, A. J., Smith, M. K., Summers, M. M., Wright, C. D., Knight, J. K., Mm, S., Cd, W., & Phys-maps, K. J. K. (2020). *Phys-MAPS : a programmatic physiology assessment for introductory and advanced undergraduates*. 15–27. <https://doi.org/10.1152/advan.00128.2018>
- Sesli, E., & Kara, Y. (2012). Development and application of a two-tier multiple-choice diagnostic test for high school students' understanding of cell division and reproduction. *Journal of Biological Education*, 46(4), 214–225. <https://doi.org/10.1080/00219266.2012.688849>
- Shulman, L. (1987). Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review*. <https://doi.org/10.17763/haer.57.1.j463w79r56455411>
- Sihombing, E. H. J. (2016). *Perbandingan Kelengkapan, Keluasan, Kedalaman Isi Buku Biologi SMA Indonesia dengan Buku Terbitan Cambridge pada Topik Enzim*. Universitas Negeri Medan.
- Simos, P. G., Breier, J. I., Fletcher, J. M., Foorman, B. R., Bergman, E., Fishbeck, K., & Papanicolaou, A. C. (2000). Brain activation profiles in dyslexic children during non-word reading: a magnetic source imaging study. *Neuroscience Letters*, 290(1), 61–65. [https://doi.org/10.1016/S0304-3940\(00\)01322-7](https://doi.org/10.1016/S0304-3940(00)01322-7)
- Slameto, S. (2016). Supervisi Pendidikan Oleh Pengawas Sekolah. *Kelola: Jurnal Manajemen Pendidikan*, 3(2), 192–206. <https://doi.org/10.24246/j.jk.2016.v3.i2.p192-206>
- Small, E. (1989). Systematics of biological systematics (or, taxonomy of taxonomy). *Taxon*, 38(3), 335–356. <https://doi.org/10.2307/1222265>

- Small, E. (1993). The economic value of plant systematics in Canadian agriculture. *Canadian Journal of Botany*, 71(12), 1537–1551. <https://doi.org/10.1139/b93-188>
- Smith, P. S. (2009). Exploring the relationship between teacher content knowledge and student learning. *Proceedings of the NARST 2009 Annual Meeting*, 1–15.
- Sober, E. (2014). Philosophy of Biology. In *Dimensions of Philosophy Series* (Second). Routledge.
- Sorgo, A. (2010). Connecting Biology and Mathematics : First Prepare the Teachers orgo. *CBE-Life Sciences Education*, 9, 196–200. <https://doi.org/10.1187/cbe.10>
- Sriyati, S., Rustaman, N., & Zainul, A. (2009). *Peran bagan konsep sebagai bentuk asesmen formatif dalam meningkatkan motivasi belajar mahasiswa pada mata kuliah botani phanerogamae*. 1–9.
- Steel; Kesley; Morita. (2004). The Truth About Science : A middle school curriculum teaching the scienti ® c method and data analysis in an ecology context. *Environmental and Ecological Statistics*, 11, 21–19.
- Stern, E. (2005). Pedagogy meets neuroscience. *Science*, 310(5749), 745. <https://doi.org/10.1126/science.1121139>
- Stern, L., & Roseman, J. E. (2004). *Can Middle-School Science Textbooks Help Students Learn Important Ideas ? Findings from Project 2061 ' s Curriculum Evaluation Study : Life Science*. 41(6), 538–568. <https://doi.org/10.1002/tea.20019>
- Stewart, J., & Kirk, J. Van. (2007). *Understanding and problem - solving in classical genetics Understanding and problem-solving in classical genetics*. December 2014, 37–41. <https://doi.org/10.1080/0950069900120509>
- Stith, B. J. (2004). *Essays Use of Animation in Teaching Cell Biology*. 3, 181–188. <https://doi.org/10.1187/cbe.03-10-0018>
- Stuessy, T. F. (2020). Challenges facing systematic biology. *Taxon*, 69(4), 655–667. <https://doi.org/10.1002/tax.12279>
- Subandi, Ahmadi, Amirudin, Mispani, Hadiati, E., & Saregar, A. (2020). Science teacher' leadership styles and competencies from the perspective of high school students: A path analysis study. *Journal for the Education of Gifted Young Scientists*, 8(4), 1535–1545. <http://10.0.68.70/jegys.831070%0Ahttps://aces.bibl.ulaval.ca/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=147781877&%0Alang=fr&site=ehost-live>
- Sukardi, R. R., Widodo, A., & Sopandi, W. (2017). *Describing Teachers' Pedagogic Content Knowledge about Reasoning Development and Students' Reasoning Test*. 57(ICMSEd 2016), 14–20. <https://doi.org/10.2991/icmsed-2022>
- Susanti Wulandari, 2022
Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
 Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

16.2017.4

- Sulistiyanto, H., & Wiyono, E. (2008a). Ilmu Pengetahuan Alam Kelas 5. In *Pusat Perbukuan Departemen Pendidikan Nasional*. Pusat Perbukuan Departemen Pendidikan Nasional.
https://bsd.pendidikan.id/data/SD_5/Ilmu_Pengetahuan_Alam_Kelas_5_Heri_Sulistiyanto_Eddy_Wiyono_2008.pdf
- Sulistiyanto, H., & Wiyono, E. (2008b). Ilmu Pengetahuan Alam Untuk SD dan MI Kelas VI. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9). Pusat Perbukuan Departemen Pendidikan Nasional.
- Sunaryati, A. N. (2015). *Analisis Kesiambungan Konsep Sistem Pernapasan dalam Buku Pelajaran Sains/Biologi Berdasarkan KTSP pada Jenjang Pendidikan SD, SMP, dan SMA*. Universitas Negeri Yogyakarta.
- Surata, I. K., Sudiana, I. M., & Sudirgayasa, I. G. (2020). Meta-Analisis Media Pembelajaran pada Pembelajaran Biologi I Ketut Surata I Made Sudiana I Gede Sudirgayasa. *Journal of Education Technology*, 4(1), 22–27.
- Susanto, A., Raharjo, & Prastiwi, M. S. (2012). Permainan Monopoli sebagai Media Pembelajaran Sub Materi Sel pada Siswa SMA Kelas XI IPA. *BioEdu*, 1(1), 1–6.
- Susilaningrum, S. (2011). *Analisis Permasalahan Siswa Dalam Memahami Pelajaran IPA Biologi Kelas VII Kompetensi Dasar Mendeskripsikan Keragaman pada Sistem Organisasi Kehidupan Mulai dari Tingkat Sel sampai Organisme di SMP AT-Thohiriyah Semarang Tahun Ajaran 2010/2011*. Institut Agama Islam Negeri Walisonong.
- Suwarno, S. (2009). *Panduan Pembelajaran Biologi Untuk SMA & MA Kelas XII* (R. Riswanti (ed.)). Pusat Perbukuan Dpartemen Pendidikan Nasional.
- Suwono, H., Prasetyo, T. I., Lestari, U., Lukiati, B., Kusairi, S., Saefi, M., & Fauzi, A. (2019). Cell Biology Diagnostic Test (CBD-Test) portrays pre-service teacher misconceptions about biology cell Cell Biology Diagnostic Test (CBD-Test) portrays pre-service. *Journal of Biological Education*, 00(00), 1–24. <https://doi.org/10.1080/00219266.2019.1643765>
- Tamir, P. (1988). Subject Matter and Related Pedagogical in Teacher Education *. *Teaching and Teacher Education*, 4(2), 99–110.
- Tanner, K., & Allen, D. (2002). Approaches to cell biology teaching: A primer on standards. *Cell Biology Education*, 1(4), 95–100. <https://doi.org/10.1187/cbe.02-09-0046>
- Tanner, K. D., Chatman, L., & Allen, D. (2003). Approaches to Biology Teaching and Learning : School – University Divide — Cultivating Conversations through Scientist – Teacher Partnerships. *Cell Biology Education*, 2, 195–201.
- Tansley, A. (1987). What is Ecology ? *Biological Journal*, 32, 5–16.
- Susanti Wulandari, 2022
Kedalaman dan Keluasan Konten Biologi yang Harus dikuasai oleh Guru
Universitas Pendidikan Indonesia | repository.upi.edu | perpustakaan.upi.edu

- Tekkaya, C., Akyol, G., & Sungur, S. (2012). Relationships among Teachers' Knowledge and Beliefs Regarding the Teaching of Evolution: A Case for Turkey. *Evolution: Education and Outreach*, 5(3), 477–493. <https://doi.org/10.1007/s12052-012-0433-y>
- Thair, M., & Treagust, D. F. (2003). A brief history of a science teacher professional development initiative in Indonesia and the implications for centralised teacher development. *International Journal of Educational Development*, 23(2), 201–213. [https://doi.org/10.1016/S0738-0593\(02\)00014-7](https://doi.org/10.1016/S0738-0593(02)00014-7)
- Topçu, M. S., & N-pekmez, E. Ş. A. H. İ. (2009). *Turkish Middle School Students' Difficulties in Learning Genetics Concepts*. 6(2), 55–62.
- Tsani, U. L., Marianti, A., & Utami, N. R. (2016). Efektivitas Model Pembelajaran Berbasis Proyek dengan Metode Gallery Walk pada Pembelajaran Materi Sel di SMA. *Unnes Journal of Biology Education*, 5(1), 31–37.
- Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing Science Teachers' Pedagogical Content Knowledge. *Journal of Research in Science Teaching*, 35(6), 673–695. [https://doi.org/10.1002/\(SICI\)1098-2736\(199808\)35:6<673::AID-TEA5>3.0.CO;2-J](https://doi.org/10.1002/(SICI)1098-2736(199808)35:6<673::AID-TEA5>3.0.CO;2-J)
- Venville, G., Gribble, S. J., & Donovan, J. (2005). *An Exploration of Young Children's Understandings of Genetics Concepts from Ontological and Epistemological*. <https://doi.org/10.1002/sce.20061>
- Wardhono, V. J. W. (1990). Penelitian apakah. *Bina Ekonomi Majalah Ilmiah Fakultas Unpar*, 23–35.
- Webb, P., & Boltt, G. (2010). Food chain to food web : a natural progression ? Food chain to food web : a natural progression ? *Journal of Biological Education*, 24(3), 37–41. <https://doi.org/10.1080/00219266.1990.9655139>
- Wells, N. M., & Evans, G. W. (2003). Environment and Behavior NEARBY NATURE A Buffer of Life Stress Among Rural Children. *Environment*, 35(3), 311–330. <https://doi.org/10.1177/0013916503251445>
- Widodo, A. (2017). Experienced biology teachers' pedagogical content knowledge (PCK) on photosynthesis. *AIP Conference Proceedings*, 1848(May). <https://doi.org/10.1063/1.4983985>
- Widodo, W., Rachmadiarti, F., & Hidayati, S. N. (2017). *Ilmu Pengetahuan Alam Kurikulum 2013 SMP/MTs Kelas VII Semester 1*. Pusat Kurikulum dan Perbukuan. https://bsd.pendidikan.id/data/2013/kelas_7smp/siswa/Kelas_07_SMP_Ilmu_Pengetahuan_Alam_IPA_S1_Siswa_2017.pdf
- Wulandari, S. (2017). Interdisciplinary Thinking Skill of Upper Secondary Students' Through Argumentation Analysis in STEM-Based Instruction on Plant Reproduction. In *Biology Education Study Programme, Graduate*

School. Universitas Pendidikan Indonesia.

- Wulandari, S., Rustaman, N. Y., Widodo, A., & Aryantha, I. N. P. (2020). *Biosistematika dan Taksonomi Untuk Sekolah Dasar dan Sekolah Menengah*. 1(229), 153–159.
- Wulandari, S., Rustaman, N. Y., Widodo, A., & Aryantha, I. N. P. (2021). What Should be Mastered by Elementary , Junior and Senior High School Teachers Related to the Concept of Evolution ? *European Online Journal on Natural and Social Sciences*, 10(1), 9–18.
- Wulandari, S., & Widodo, A. (2020). *How Do Students Understand the Material of Animal Kingdom? (Development Invertebrate Learning Material Based on Students' Prior Knowledge)*. 438(Aes 2019), 129–131. <https://doi.org/10.2991/assehr.k.200513.029>
- Yanti, E. E., & Setiadi, A. E. (2017). Pengembangan Media Pembelajaran Biologi Berbasis Adobe Flash pada Materi Pembelahan Sel Kelas XII SMA Negeri 1 Sungai Raya. *Jurnal Bioeducation*, 2(1), 15–24.
- Yates, T. B., & Marek, E. A. (2014). Teachers teaching misconceptions: A study of factors contributing to high school biology students' acquisition of biological evolution-related misconceptions. *Evolution: Education and Outreach*, 7(1), 1–18. <https://doi.org/10.1186/s12052-014-0007-2>
- Yudianto, S. A. (2010). *Menggunakan Pendekatan Pasangan Konsep*. 229, 1–15.
- Zago, L., Pesenti, M., Mellet, E., Crivello, F., Mazoyer, B., & Tzourio-Mazoyer, N. (2001). Neural correlates of simple and complex mental calculation. *NeuroImage*, 13(2), 314–327. <https://doi.org/10.1006/nimg.2000.0697>
- Zamer, W. E., & Scheiner, S. M. (2014). A conceptual framework for organismal biology: linking theories, models, and data. *Integrative and Comparative Biology*, 54(5), 736–756. <https://doi.org/10.1093/icb/icu075>
- Zubaidah, S., Mahanal, S., & Yuliati, L. (2017). *Ilmu Pengetahuan Alam kelas IX semester 1*. Kementerian Pendidikan dan Kebudayaan.
- Zubaidah, S., Mahanal, S., Yuliati, L., Dasna, I. W., Pangerstuti, A. A., Puspitasari, D. R., Mahfudhillah, H. T., Robitah, A., Kurniawati, Z. L., Rosyida, F., & Sholihah, M. (2017). Ilmu Pengetahuan Alam Untuk SMP/MTs Kelas VIII Semester 2 ISBN. In *Kementerian Pendidikan dan Kebudayaan* (Vol. 53, Issue 9). Kementerian Pendidikan dan Kebudayaan.

