DEVELOPMENT OF AUGMENTED REALITY FOR SPECIAL EDUCATION NEEDS (ARSEN) IN AN INCLUSIVE CLASSROOM TO ENHANCE STUDENTS' SCIENTIFIC CONCEPTIONS ON HEAT

Bachelor Thesis

Submitted as Requirement to Obtain Degree of *Sarjana Pendidikan* in
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DECLARATION OF ORIGINALITY

I hereby declare that the thesis entitled "**Development of Augmented Reality for Special Education Needs (ARSEN) in an Inclusive Classroom to Enhance Students' Scientific Conceptions of Heat** " and all its contents are really my own work. I do not plagiarize or cite in ways that are in accordance with the ethics of science that apply in the scientific community. For this statement, I am ready to bear the risk/sanction if in the future it is found that there is a violation of scientific ethics or there are claims from other parties against the authenticity of my work.

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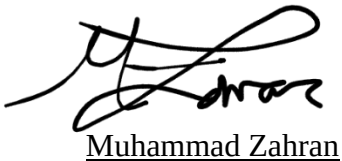

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PREFACE

All praise be to Allah SWT, the Almighty God, for His blessings and grace, through which the author has been granted guidance and ease in completing this thesis entitled "Development of Augmented Reality for Special Education Needs (Arsen) to Enhance Students' Scientific Conceptions of Heat in an Inclusive Classroom."

This thesis was prepared as a final project to fulfill the requirements for the degree of *Sarjana Pendidikan* (S1) in the Physics Education Study Program, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia.

The author sincerely hopes that this thesis will be beneficial to readers and may serve as a valuable reference for further development in the field. This work could not have been accomplished without the support, assistance, guidance, and advice from many individuals throughout the process.

The author is fully aware that this thesis still has several shortcomings and thus welcomes any constructive criticism and suggestions to improve future work.

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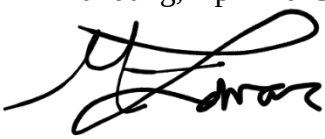

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DEVELOPMENT OF AUGMENTED REALITY FOR SPECIAL EDUCATION NEEDS (ARSEN) IN AN INCLUSIVE CLASSROOM TO ENHANCE STUDENTS' SCIENTIFIC CONCEPTIONS ON HEAT

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ABSTRACT

Understanding scientific concepts in physics, especially the concept of heat, remains challenging for many students due to its abstract nature. This difficulty is more pronounced among students with special needs, who often encounter additional barriers in accessing inclusive and effective learning experiences. To address this issue, this study developed ARSEN (Augmented Reality for Special Education Needs), an AR-based learning media designed to enhance students' conceptions of heat in inclusive classrooms. The study employed a development research methodology based on the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) involving 11 experts and 13 students. Six experts validated ARSEN's content and construct, while five others evaluated the HCF-TT (Heat Concept Four-Tier Test) used to investigate students' conceptions pre- and post-intervention. Instruments included ARSEN and HCF-TT validation sheets, the HCF-TT itself, and a student response sheet. Results showed that ARSEN is valid, practical, and effective as a learning media. Based on Many-Facet Rasch Measurement (MFRM) analysis, expert agreement reached 73% for content validity and 61% for construct validity across 45 indicators. The average practicality score was 3.34, classified as very practical (83%). Effectiveness was demonstrated through normalized change (N-change) scores ranging from 0.07 to 0.65, indicating varying degrees of conceptual improvement. In conclusion, ARSEN offers a promising approach for inclusive physics education. By integrating augmented reality with inclusive strategies, it provides interactive and accessible learning experiences that support students with special needs in grasping complex scientific concepts like heat.

Keywords: Augmented Reality, Special Education Needs, Enhancement of Scientific Conceptions, Conceptual Change, Many-Facet Rasch Measurement.

PENGEMBANGAN *AUGMENTED REALITY FOR SPECIAL EDUCATION NEEDS* (ARSEN) DI KELAS INKLUSI UNTUK MENINGKATKAN KONSEPSI ILMIAH SISWA TENTANG KALOR

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ABSTRACT

Konsep kalor dalam fisika bersifat abstrak sehingga sulit dipahami oleh banyak siswa, terutama mereka yang memiliki kebutuhan khusus. Hambatan dalam memahami materi ini menjadi tantangan dalam mewujudkan pembelajaran yang inklusif dan efektif. Untuk mengatasi hal tersebut, penelitian ini mengembangkan ARSEN (Augmented Reality for Special Education Needs), sebuah media pembelajaran berbasis augmented reality yang dirancang untuk membantu siswa memahami konsep kalor di kelas inklusi. Penelitian ini menggunakan model pengembangan ADDIE (Analysis, Design, Development, Implementation, and Evaluation) dan melibatkan 11 ahli serta 13 siswa. Enam ahli memvalidasi konten dan konstruk ARSEN, sedangkan lima ahli lainnya mengevaluasi instrumen HCF-TT (Heat Concept Four-Tier Test) yang digunakan untuk mengukur konsepsi siswa sebelum dan sesudah penggunaan ARSEN. Instrumen penelitian meliputi lembar validasi, HCF-TT, dan lembar respons siswa. Hasil analisis menggunakan Many-Facet Rasch Measurement (MFRM) menunjukkan bahwa ARSEN memiliki tingkat validitas konten sebesar 73% dan validitas konstruk sebesar 61% dari 45 indikator. Kepraktisan ARSEN memperoleh skor rata-rata 3,34 (sangat praktis, 83%). Efektivitas media ini terlihat dari skor perubahan ternormalisasi (N-change) siswa yang berkisar antara 0,07 hingga 0,65, mengindikasikan peningkatan konseptual yang bervariasi. Kesimpulannya, ARSEN merupakan media pembelajaran yang valid, praktis, dan efektif untuk mendukung pemahaman konsep kalor, khususnya bagi siswa berkebutuhan khusus di kelas inklusi. Integrasi augmented reality dengan strategi pembelajaran inklusif memberikan pengalaman belajar yang lebih interaktif dan mudah diakses.

Keywords: Augmented Reality, Kebutuhan Khusus, Peningkatan Konsepsi Ilmiah, Perubahan Konseptual, Many-Facet Rasch Measurement.

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Abdusselam, M. S., & Karal, H. (2020). The effect of using augmented reality and sensing technology to teach magnetism in high school physics. *Technology, Pedagogy and Education*, *29*(4), 407–424.

Abu-Dalbouh, H. M., AlSulaim, S. M., AlDera, S. A., Alqaan, S. E., Alharbi, L. M., & AlKeraida, M. A. (2020). An application of physics experiments of high school by using augmented reality. *IJSEA*, *11*, 37–49.

Adimayuda, R., Sari, L., Ismail, A., Amalia, I. F., Gumilar, S., & Samsudin, A. (2021). Assessing two-dimensional collisions second-years students using PhET simulations on momentum and impulse concept. *Journal of Physics: Conference Series*, *1869*(1). https://doi.org/10.1088/1742-6596/1869/1/012204

Aftab, M. J., Amjad, F., & Chaudhry, H. (2024). Exploring the Role of AI-Driven Speech Recognition System in Supporting Inclusive Education for Hearing Impaired Students in Pakistan. *Annals of Human and Social Sciences*, *5*(3), 492–504.

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, *20*, 1–11. https://doi.org/https://doi.org/10.1016/j.edurev.2016.11.002

Alnahdi, G. (2014). Assistive technology in special education and the universal design for learning. *Turkish Online Journal of Educational Technology-TOJET*, *13*(2), 18–23.

Alper, S., & Raharinirina, S. (2006). Assistive technology for individuals with disabilities: A review and synthesis of the literature. *Journal of Special Education Technology*, *21*(2), 47–64.

Aminudin, A. H., Adimayuda, R., Kaniawati, I., Suhendi, E., Samsudin, A., & Coştu, B. (2019). Rasch analysis of Multitier Open-ended Light-Wave Instrument (MOLWI): Developing and assessing second-years sundanese-scholars alternative conceptions. *Journal for the Education of Gifted Young Scientists*, *7*(3), 557–579. https://doi.org/10.17478/jegys.574524

Arriani, F., Agustiawati, A., Rizki, A., Widiyanti, R., Wibowo, S., Herawati, F., & Tulalessy, C. (2021). *Panduan pelaksanaan pendidikan inklusif*.

Astuti, W. P., Ramli, M., & Suranto, S. (2022). Validity and practicality of sangiran site-based virtual laboratory learning media on evolutionary materials to

empower science literacy. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1378–1384.

Azuma, R. T. (1997). A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments*, *6*(4), 355–385. https://doi.org/10.1162/pres.1997.6.4.355

Bakri, F., & Dwijayanti, D. (2022). Physics Textbook Enriched with Videos Based on Augmented Reality Technology: Practice in Problem Solving Skill in Dynamics of Rotation Concept for Senior High School Students. *Journal of Physics: Conference Series*, *2377*(1), 012079.

Bañados, M. R. L., Sulfelix, J. N. S., Baste, J. D., Gatus, J. T. C., Rafanan, R. V. P., & Cagape, W. E. (2024a). INNOVATIVE TEACHING APPROACHES OF TEACHERS IN TEACHING STUDENTS WITH SPECIAL NEEDS: A CASE STUDY. *INNOVATIVE TEACHING APPROACHES OF TEACHERS IN TEACHING STUDENTS WITH SPECIAL NEEDS: A CASE STUDY*, *146*(1), 15.

Bang, S. Y., Kwon, N. J., & Kwon, G. P. (2023). Effect of Science Class Using Augmented Reality (AR) on Conceptual Change of Magnetic Field due to a Current in Middle School Students. *New Physics: Sae Mulli*, *73*(6), 494–504. https://doi.org/10.3938/NPSM.73.494

Baragash, R. S., Al-Samarraie, H., Alzahrani, A. I., & Alfarraj, O. (2020). Augmented reality in special education: a meta-analysis of single-subject design studies. *European Journal of Special Needs Education*, *35*(3), 382–397. https://doi.org/10.1080/08856257.2019.1703548

Başer, M. (2006). Fostering conceptual change by cognitive conflict based instruction on students' understanding of heat and temperature concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, *2*(2), 96–114.

Bawaneh, A. K. A., Zain, A. N. M., Saleh, S., & Abdullah, A. G. K. (2012). The Effect of a Brain-Based Teaching Method on Conceptual Change in Students' Understanding of Electricity. *International Journal of Physics and Chemistry Education*, *4*(2), 79–96.

Bilad, M. R., Zubaidah, S., & Prayogi, S. (2024). Addressing the PISA 2022 Results: A Call for Reinvigorating Indonesia's Education System. *International Journal of Essential Competencies in Education*, *3*(1), 1–12. https://doi.org/10.36312/ijece.v3i1.1935

Bond, T. G., & Fox, C. M. (2013). *Applying the Rasch model: Fundamental measurement in the human sciences*. Psychology Press.

Brill, S. J. C., & Bondezan, A. N. (2024). Unveiling challenges: Inclusive literacy of children with intellectual disabilities in the Brazilian school context. *Seven Publicações Acadêmicas*. https://doi.org/10.56238/sevenvimulti2024-030

Cai, S., Liu, C., Wang, T., Liu, E., & Liang, J. (2021). Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning. *British Journal of Educational Technology*, *52*(1), 235–251.

Caleon, I. S., & Subramaniam, R. (2010). Do students know what they know and what they don't know? Using a four-tier diagnostic test to assess the nature of students' alternative conceptions. *Research in Science Education*, *40*, 313–337.

Cheng, K.-H., & Tsai, C.-C. (2013). Affordances of augmented reality in science learning: Suggestions for future research. *Journal of Science Education and Technology*, *22*, 449–462.

Chi, M. T. H., Slotta, J. D., & De Leeuw, N. (1994). From things to processes: A theory of conceptual change for learning science concepts. *Learning and Instruction*, *4*(1), 27–43. https://doi.org/https://doi.org/10.1016/0959-4752(94)90017-5

Chu, H.-E., Treagust, D. F., Yeo, S., & Zadnik, M. (2012). Evaluation of students' understanding of thermal concepts in everyday contexts. *International Journal of Science Education*, *34*(10), 1509–1534.

Clarke, V., & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology*, *12*(3), 297–298.

Cook, A. M., & Polgar, J. M. (2014). *Assistive technologies-e-book: principles and practice*. Elsevier Health Sciences.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Devialita, A., Suhandi, A., Samsudi, A., Hendriyani, D., Purwanto, M. G., Riani, V. R., Nurzakiyah, E., & Gitnita, S. (2021). Analysis conception of secondary student's using four tier test on heat and temperature. *Journal of Physics: Conference Series*, *2098*(1), 012002.

Doulah, A. B. M. S. U., Rasheduzzaman, M., Arnob, F. A., Sarker, F., Roy, N., Ullah, Md. A., & Mamun, K. A. (2023). Application of Augmented Reality Interventions for Children with Autism Spectrum Disorder (ASD): A Systematic Review. *Computers*, *12*(10). https://doi.org/10.3390/computers12100215

Driver, R. (1989). Students' conceptions and the learning of science. *International Journal of Science Education*, *11*(5), 481–490.

Duit, R., & Treagust, D. F. (2003). Conceptual change: A powerful framework for improving science teaching and learning. *International Journal of Science Education*, *25*(6), 671–688.

Eckes, T. (2023). *Introduction to many-facet Rasch measurement*. Peter Lang.

Fan, X., Geelan, D., & Gillies, R. (2018). Evaluating a novel instructional sequence for conceptual change in physics using interactive simulations. *Education Sciences*, *8*(1), 29.

Febrianti, J., Akhsan, H., & Muslim, M. (2019). ANALISIS MISKONSEPSI SUHU DAN KALOR PADA SISWA SMA NEGERI 3 TANJUNG RAJA. *Journal of Innovation and Physics Learning*, *06*(1), 90–102.

Fernández-López, Á., Rodríguez-Fórtiz, M. J., Rodríguez-Almendros, M. L., & Martínez-Segura, M. J. (2013). Mobile learning technology based on iOS devices to support students with special education needs. *Computers & Education*, *61*, 77–90.

Finkelstein, N., Adams, W., Keller, C., Perkins, K., & Wieman, C. (2006). High-tech tools for teaching physics: The physics education technology project. *Merlot Journal of Online Learning and Teaching*, *2*(3), 110–121.

Galili, I. (1996). Students' conceptual change in geometrical optics. *International Journal of Science Education*, *18*(7), 847–868.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction*. Longman Publishing.

Garzón, J., Pavón, J., & Baldiris, S. (2019). Systematic review and meta-analysis of augmented reality in educational settings. *Virtual Reality*, *23*(4), 447–459.

Goguen, J. (2005). What is a concept? *International Conference on Conceptual Structures*, 52–77.

Goncharenko, T., Yermakova-Cherchenko, N., & Anedchenko, Y. (2020). *Experience in the use of mobile technologies as a physics learning method*.

Haryadi, R., & Pujiastuti, H. (2020). *The Effectiveness of Using Serious Games to Improve Physics Learning Outcomes in Light Concept*. https://doi.org/10.21009/1

Haryono, H. E., Aini, K. N., Samsudin, A., & Siahaan, P. (2021). Reducing the students' misconceptions on the theory of heat through cognitive conflict

instruction (CCI). *AIP Conference Proceedings, 2330*. https://doi.org/10.1063/5.0043400

Haryono, H. E., Samsudin, A., Aini, K. N., & Siahaan, P. (2021). Teams' games tournaments with cognitive conflict instruction (CCI) model to unveil students' misconceptions. *Cypriot Journal of Educational Sciences, 16*(4), 1343–1356. https://doi.org/10.18844/cjes.v16i4.5983

Hermita, N., Ningsih, H. S., Alim, J. A., Alpusari, M., Putra, Z. H., & Wijaya, T. T. (2020). Developing science comics for elementary school students on animal diversity. *Solid State Technology*, *63*(1s), 2492–2500.

Hjørland, B. (2009). Concept theory. *Journal of the American Society for Information Science and Technology*, *60*(8), 1519–1536.

Huang, Y.-C., & Lee, I.-J. (2020). Using augmented reality and concept mapping to improve ability to master social relationships and social reciprocity for children with autism Spectrum disorder. *Universal Access in Human-Computer Interaction. Applications and Practice: 14th International Conference, UAHCI 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part II 22*, 19–37.

Ibáñez, M.-B., & Delgado-Kloos, C. (2018). Augmented reality for STEM learning: A systematic review. *Computers & Education*, *123*, 109–123. https://doi.org/https://doi.org/10.1016/j.compedu.2018.05.002

Irwansyah, I., Sukarmin, S., & Harjana, H. (2018). Development of Three-Tier Diagnostics Instruments on Students Misconception Test in Fluid Concept. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *7*(2), 207–217. https://doi.org/10.24042/jipfalbiruni.v7i2.2703

Islim, O. F., Ozcakir, B., Ozkubat, U., Sanir, H., Sevim-Cirak, N., Solmaz, E., Uluay, G., & Ogdem, Z. (2024a). A needs analysis study for the development of augmented reality applications in science and mathematics teaching for individuals with special educational needs. *Education and Information Technologies*, *29*(10), 12197–12227. https://doi.org/10.1007/s10639-023-12339-7

Ismail, A., Rahayu, G., Putera, M. A. K., Aghniya, N. N., & Gumilar, S. (2021). Development of augmented reality as physics learning media on electric concepts. *IOP Conference Series: Materials Science and Engineering*, *1098*(4), 042006.

Jackendoff, R. (1989). What is a concept, that a person may grasp it? 1. *Mind & Language*, *4*(1-2), 68–102.

Jackendoff, R. (2012). What is a concept? In *Frames, Fields, and Contrasts* (pp. 191–208). Routledge.

Jander, S., Brill, C., & Nakamura Bondezan, A. (2024, May 2). Unveiling challenges: Inclusive literacy of children with intellectual disabilities in the Brazilian school context. *Seven Publicações Acadêmicas*.

Jdaitawi, M., Muhaidat, F., Alsharoa, A., Alshlowi, A., Torki, M., & Abdelmoneim, M. (2023). The Effectiveness of Augmented Reality in Improving Students Motivation: An Experimental Study. *Athens Journal of Education*, *10*(2), 365–379.

Jdaitawi, M. T., & Kan'an, A. F. (2022). A Decade of Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education. In *Contemporary Educational Technology* (Vol. 14, Issue 1). Anadolu University, Faculty of Communication Sciences. https://doi.org/10.30935/cedtech/11369

Julaila, Y., Fauzi, A., Wahyuningsih, D., & Samsudin, A. (2021). Development of MATTERED (modul of heat and temperature based on android) for senior high school. *Journal of Physics: Conference Series*, *2098*(1). https://doi.org/10.1088/1742-6596/2098/1/012007

Kaltakci-Gurel, D., Eryilmaz, A., & McDermott, L. C. (2017). Development and application of a four-tier test to assess pre-service physics teachers' misconceptions about geometrical optics. *ReseaRch in Science & Technological EducaTion*, *35*(2), 238–260.

Kaniawati, I., Danawan, A., Suyana, I., Samsudin, A., & Suhendi, E. (2021). Implementation of Interactive Conceptual Instruction (ICI) With Computer Simulation: Impact of Students' Misconceptions on Momentum and Impulse Material. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *10*(1), 1–17. https://doi.org/10.24042/jipfalbiruni.v10i1.8375

Kaniawati, I., Rahmadani, S., Fratiwi, N. J., Suyana, I., Danawan, A., Samsudin, A., & Suhendi, E. (2020). An analysis of students' misconceptions about the implementation of active learning of optics and photonics approach assisted by computer simulation. *International Journal of Emerging Technologies in Learning*, *15*(9), 76–93. https://doi.org/10.3991/ijet.v15i09.12217

Kanli, U. (2014). A study on identifying the misconceptions of pre-service and in-service teachers about basic astronomy concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(5), 471–479.

Kapetanaki, A., Krouska, A., Troussas, C., & Sgouropoulou, C. (2022). Exploiting augmented reality technology in special education: a systematic review. *Computers*, *11*(10), 143.

Kapul, M., Lantik, V., & Astiti, K. A. (2023). Analisis Miskonsepsi Siswa dan Alternatif Remediasinya pada Konsep Suhu dan Kalor. *Jurnal Pendidikan Dan Pembelajaran IPA Indonesia*, *13*(1), 17–23.

Kokkonen, T., Lichtenberger, A., & Schalk, L. (2022). Concreteness fading in learning secondary school physics concepts. *Learning and Instruction*, *77*, 101524.

Komarudin, K., & Kaeni, N. F. (2023). The Obstacles of Inclusive Education Implementation in Indonesia: A Systematic Review. *GUIDENA: Jurnal Ilmu Pendidikan, Psikologi, Bimbingan Dan Konseling*, *12*(3), 382. https://doi.org/10.24127/gdn.v12i3.6537

Kotsis, K. T., Stylos, G., Houssou, P., & Kamaratos, M. (2023). Students' perceptions of the heat and temperature concepts: A comparative study between primary, secondary, and university levels. *European Journal of Education and Pedagogy*, *4*(1), 136–144.

Lange, B., Koenig, S., McConnell, E., Chang, C.-Y., Juang, R., Suma, E., Bolas, M., & Rizzo, A. (2012). Interactive game-based rehabilitation using the Microsoft Kinect. *Virtual Reality Conference, Ieee*, 171–172.

Leacock, T. L., & Nesbit, J. C. (2007). A framework for evaluating the quality of multimedia learning resources. *Journal of Educational Technology & Society*, *10*(2), 44–59.

Lebdiana, R., Suhaldi, & Hindarto, N. (2013). Pengembangan Perangkat Pembelajaran Materi Suhu dan Kalor Berbasis POE (Predict-Observe-Explain) untuk Meremediasi Miskonsepsi Siswa. *Unnes Physics Education Journal*, *4*(2), 1–6. http://journal.unnes.ac.id/sju/index.php/upej

Li, Y., & Singh, C. (2022). Inclusive learning environments can improve student learning and motivational beliefs. *Physical Review Physics Education Research*, *18*(2). https://doi.org/10.1103/PhysRevPhysEducRes.18.020147

Liem, S. S. (2024). Peningkatan Kualitas Guru Sekolah Penyelenggara Pendidikan Inklusif dan Terapis di Kota Surakarta. *Jurnal Abdi Rakyat*, *1*(1). https://bbgpjabar.kemdikbud.go.id/permasalahan-pendidikan-inklusif-di-

Linacre, J. M. (2002). Optimizing rating scale category effectiveness. *Journal of Applied Measurement*, *3*(1), 85–106.

Linacre, J. M., & Wright, B. D. (2014). Facets. *Computer Program for Many-Faceted Rasch Measurement*, 1998.

Marx, J. D., & Cummings, K. (2007). Normalized change. *American Journal of Physics*, *75*(1), 87–91.

Molenda, M. (2003). In search of the elusive ADDIE model. *Performance Improvement*, *42*(5), 34–37.

Muksalmina, M., Istiarsyah, I., Kamarullah, K., & Sabaruddin, S. (2024). How Effective is Differentiated Instruction Model for Special Needs Students? Perspectives of Inclusive Teachers. *Proceeding of International Conference on Special Education in South East Asia Region*. https://doi.org/10.57142/picsar.v3i1.58

Murniarti, E., Prayitno, H., Wibowo, G. A., Suparmi, S., Yuliani, E., & Rochmah, R. (2023). Implementing Augmented Reality in Inclusive Education: Experiments and Potential. *International Journal of Science and Society*, *5*(4), 60–72.

Nieveen, N. (1999). Prototyping to reach product quality. *Design Approaches and Tools in Education and Training*, 125–135.

Nieveen, N. M. (1997). *Computer support for curriculum developers: A study on the potential of computer support in the domain of formative curriculum evaluation*.

Noyes, J., & Frankish, C. (1992). Speech recognition technology for individuals with disabilities. *Augmentative and Alternative Communication*, *8*(4), 297–303.

Nurhasanah, N., Samsudin, A., Linuwih, S., & Sutrisno, A. D. (2022). Is SiPOERT an Innovative Learning? Implementation and Identification of Students' Conception on Simple Harmonic Motion. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *5*(1), 78–91. https://doi.org/10.23917/ijolae.v5i1.19567

Nurjanah, S., Sultan, J., Arriza, L., Suardi, I. K., Ramadhani, S., Seran, D. S. F., & Rashid, S. (2025). Assessment in physics education research: Trends, patterns, and future directions. *Review of Education*, *13*(1), e70043.

Nurul, S., Silung, W., Kusairi, S., & Zulaikah, S. (2016). Diagnosis Miskonsepsi Siswa SMA di Kota Malang pada Konsep Suhu dan Kalor Menggunakan Three Tier Test. *Jurnal Pendidikan Fisika Dan Teknologi*, *II*(3), 95–105.

Nusroh, H., Khalif, M. A., & Saputri, A. A. (2022). Developing Physics Learning Media Based on Augmented Reality to Improve Students' Critical Thinking Skills. *Physics Education Research Journal*, *4*(1), 23–28.

Okechukwu, M., & Udoka, F. (2011). Understanding Virtual Reality Technology: Advances and Applications. *Advances in Computer Science and Engineering*, *March 2011*. https://doi.org/10.5772/15529

Önder Çelikkanlı, N., & Kızılcık, H. (2022). A review of studies about four-tier diagnostic tests in physics education. *Journal of Turkish Science Education*, *19*(4).

Ozkan, G., & Selçuk, G. S. (2012). How effective is "conceptual change approach" in teaching physics. *Journal of Educational and Instructional Studies in the World*, *2*(2), 182–190.

Pissaloux, E., & Velazquez, R. (2018). *Mobility of visually impaired people*. Springer.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, *66*(2), 211–227.

Pusat Analisis Keparlemenan Badan Keahlian DPR RI. (2024). *Tantangan dalam mewujudkan pendidikan inklusif*.

Putra, M. A., Madlazim, M., & Hariyono, E. (2024). Exploring Augmented Reality-Based Learning Media Implementation in Solar System Materials. *IJORER: International Journal of Recent Educational Research*, *5*(1), 29–41.

Raffoul, S., & Jaber, L. (2023). Text-to-Speech Software and Reading Comprehension: The Impact for Students with Learning Disabilities. *Canadian Journal of Learning and Technology*, *49*(2), 1–18.

Ramma, Y., Bholoa, A., Watts, M., & Nadal, P. S. (2018). Teaching and learning physics using technology: Making a case for the affective domain. *Education Inquiry*, *9*(2), 210–236.

Rampean, B. A. O., & Rohaeti, E. (2025). The development of an integrated instrument to measure higher order thinking skills and scientific attitudes. *Journal of Turkish Science Education*, *22*(1), 48–62.

Rosyidah, U., & Rindaningsih, I. (2024). Improving Teachers' Understanding of Inclusive Education. *International Journal Multidisciplinary*, *1*(2), 23–32. https://journal.antispublisher.com/index.php/ijmi

Sahin, D., & Yilmaz, R. M. (2020). The effect of Augmented Reality Technology on middle school students' achievements and attitudes towards science education. *Computers & Education*, *144*, 103710. https://doi.org/https://doi.org/10.1016/j.compedu.2019.103710

Samsudin, A. (2023). Conceptual Change based on Virtual Media (CC-VM) versus POE Strategy: Analysis of Mental Model Improvement and Changes on Light Wave Concepts. *International Journal of Technology in Education and Science*, *7*(2), 230–252. https://doi.org/10.46328/ijtes.449

Samsudin, A., Coştu, B., & Linuwih, S. (2022). Can sound waves in computer simulation lower students' misconceptions? Analysis of reduction and change. *World Journal on Educational Technology: Current Issues*, *14*(5), 1398–1414. https://doi.org/10.18844/wjet.v14i5.7864

Samsudin, A., Rusdiana, D., Efendi, R., Fratiwi, N. J., Aminudin, A. H., & Adimayuda, R. (2021). Development of Predict-Observe-Explain (POE) Strategy Assisted by Rebuttal Texts on Newton's Law Material with Rasch Analysis. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, *6*(1), 103–115. https://doi.org/10.24042/tadris.v6i1.7641

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., & Coştu, B. (2016). Investigating the effectiveness of an active learning based-interactive conceptual instruction (ALBICI) on electric field concept. *Asia-Pacific Forum on Science Learning and Teaching*, *17*(1), 1–41.

Samsudin, A., Suhandi, A., Rusdiana, D., Kaniawati, I., & Coştu, B. (2017). Promoting conceptual understanding on magnetic field concept through interactive conceptual instruction (ICI) with PDEODE* E tasks. *Advanced Science Letters*, *23*(2), 1205–1209.

Samsudin, A., Zulfikar, A., Saepuzaman, D., Suhandi, A., Aminudin, A. H., Supriyadi, S., & Coştu, B. (2024). Correcting grade 11 students' misconceptions of the concept of force through the conceptual change model (CCM) with PDEODE* E tasks. *Journal of Turkish Science Education*, *21*(2), 212–231.

Septian, M. F., & Burhendi, F. C. A. (2022). Pengembangan Mini Glosarium Fisika Modern Sebagai Referensi Tambahan Peserta Didik Berbasis Augmented Reality. *Jurnal Penelitian Pembelajaran Fisika*, *13*(2), 201–210. https://doi.org/10.26877/jp2f.v13i2.12451

Silung, S. N. W., Kusairi, S., & Zulaikah, S. (2016). Diagnosis miskonsepsi siswa SMA di Kota Malang pada konsep suhu dan kalor menggunakan three tier test. *Jurnal Pendidikan Fisika Dan Teknologi*, *2*(3), 95–105.

Sirakaya, M., & Cakmak, E. K. (2018). The effect of augmented reality use on achievement, misconception and course engagement. *Contemporary Educational Technology*, *9*(3), 297–314. https://doi.org/10.30935/cet.444119

Sjöström, C. (2002). *Non-visual haptic interaction design-guidelines and applications*.

Soeharto, S., & Csapó, B. (2022). Assessing Indonesian student inductive reasoning: Rasch analysis. *Thinking Skills and Creativity, 46*, 101132.

Sreenivasulu, B., & Subramaniam, R. (2013). University students' understanding of chemical thermodynamics. *International Journal of Science Education*, *35*(4), 601–635.

Staub, D., & Peck, C. A. (1995). What Are the Outcomes for Nondisabled Students?. *Educational Leadership*, *52*(4), 36–40.

Strzys, M. P., Kapp, S., Thees, M., Klein, P., Lukowicz, P., Knierim, P., Schmidt, A., & Kuhn, J. (2018). Physics holo. lab learning experience: using smartglasses for augmented reality labwork to foster the concepts of heat conduction. *European Journal of Physics*, *39*(3), 035703.

Suhandi, A., Samsudin, A., Suhendi, E., & Basori, H. (2020). Using CCOText assisted by dynamic model and analogy to fostering students' misconception about the concept of heat conduction. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022044

Sumintono, B. (2018). Rasch model measurements as tools in assesment for learning. *1st International Conference on Education Innovation (ICEI 2017)*, 38–42.

Sunanto, J., & Hidayat, H. (2016). Desain Pembelajaran Anak Berkebutuhan Khusus dalam Kelas Inklusif. *Jurnal Asesmen Dan Intervensi Anak Berkebutuhan Khusus*, *17*(1), 47–55.

Suwahyo, B. W., Setyosari, P., & Praherdhiono, H. (2021). Barrier Assistive Technology in Inclusive Classroom. *7th International Conference on Education and Technology (ICET 2021)*, 23–28.

Syahnas Nabiela, H., & Ulfatin, N. (2023). Inclusive Education Policy In Indonesia: Best Practices, Challenges, And Future Directions. *International Journal of Educational Research & Social Sciences*, *4*(6), 1007–1012. https://ijersc.org

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53.

Tippett, C. D. (2010). REFUTATION TEXT IN SCIENCE EDUCATION: A REVIEW OF TWO DECADES OF RESEARCH. *International Journal of Science and Mathematics Education*, *8*, 951–970. https://doi.org/10.1007/s10763

Tolba, E. G. A., & Youssef, N. H. (2024). Conceptual change and developing mental motivation in physics: Effects of transformational learning theory. *International Journal of Instruction*, *17*(4), 359–384.

Tosto, C., Matin, F., Seta, L., Chiazzese, G., Chifari, A., Arrigo, M., Taibi, D., Farella, M., & Mangina, E. (2022). The potential of AR solutions for behavioral learning: a scoping review. *Computers*, *11*(6), 87.

Uyuni, Q., Widodo, W., Supardi, Z. A. I., Ilhami, F. B., & Prayogi, A. (2024). Analysis of Students' Misconceptions and Their Causes with a Four-Tier Diagnostic Test on Temperature and Heat Materials Assisted by Google Form in Islamic Junior High School Students. *Jurnal IPA & Pembelajaran IPA*, *8*(4), 447–457.

Vosniadou, S. (2013). Conceptual change in learning and instruction: The framework theory approach. In *International handbook of research on conceptual change* (pp. 11–30). Routledge.

Widiasih, W., Zakirman, Z., & Ekawati, R. (2023). Development of Augmented Reality Media to Improve Student Understanding of Optical Eyes System Materials. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 912–919. https://doi.org/10.29303/jppipa.v9i2.2858

Wiliyanto, D. A., Gunarhadi, G., Anggarani, F. K., Yusuf, M., & Subagya, S. (2022). Development of augmented reality-based learning models for students with specific learning disabilities. *Cypriot Journal of Educational Sciences*, *17*(8), 2915–2926.

Wong, K.-T., Hosshan, H., Hanafi, H. F., & Mudiono, A. (2024). Augmented Reality (AR): An Assistive Technology for Special Education Needs. *Journal of Advanced Research in Applied Sciences and Engineering Technology Journal Homepage*, *35*, 97–105. https://doi.org/10.37934/araset.35.1.97105

Wood, L. A., & Robertson, A. D. (2018). Characterizing practices and resources for inclusive physics learning. *PERC Proceedings*, 448–451. https://doi.org/10.1119/perc.2017.pr.107

Wood, S. G., Moxley, J. H., Tighe, E. L., & Wagner, R. K. (2018). Does use of text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of Learning Disabilities*, *51*(1), 73–84.

Wright, B. D., & Masters, G. N. (1982). *Rating scale analysis*. MESA press.

Wulandari, T. A., & Prihandono, T. (2018). ANALISIS MISKONSEPSI SISWA PADA MATERI SUHU DAN KALOR DI KELAS XI SMA JEMBER. *SEMINAR NASIONAL PENDIDIKAN FISIKA*, *3*, 135–139.

Yang, D.-C., & Lin, Y.-C. (2015). Assessing 10-to 11-year-old children's performance and misconceptions in number sense using a four-tier diagnostic test. *Educational Research*, *57*(4), 368–388.

Yeo, J., Lim, E., Tan, K. C. D., & Ong, Y. S. (2021). The efficacy of an image-to-writing approach to learning abstract scientific concepts: Temperature and heat. *International Journal of Science and Mathematics Education*, *19*, 21–44.

Yilmaz, R. M. (2016). Educational magic toys developed with augmented reality technology for early childhood education. *Computers in Human Behavior*, *54*, 240–248.

Yoon, S., Anderson, E., Lin, J., & Elinich, K. (2017). How Augmented Reality Enables Conceptual Understanding of Challenging Science Content. In *Educational Technology & Society* (Vol. 20, Issue 1).