BIO-INOVED
Jurnal Biologi-Inovasi Pendidikan
Volume 6, Issue 3, October 2024 page. 361-369

P-ISSN : 2684-9062 | E-ISSN : 2714-9803
https://ppjp.ulm.ac.id/journal/index.php/bino
DOI: 10.20527/bino.v6i3.19379

What dominates most? The opinion of preservice biology teachers about factors associated with motivation to conduct innovative learning

Ahmad Kamal Sudrajat [(1)] *, Dita Purwinda Anggrella [(2)], Ahmad Iskak Nugroho [(3)]

[(1)] Study Program of Biology Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Sleman, Yogyakarta, Indonesia
[(2)] Study Program of Biology Education, Faculty of Tarbiyah, Universitas Islam Negeri Raden Mas Said Surakarta, Surakarta, Central Java, Indonesia
[(3)] Study Program of Science Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Malang, East Java, Indonesia

** Corresponding Author Email: kamalsudrajat@uny.ac.id*

Article Information

Keyword:
Classroom design; Curriculum design; Innovative learning; School design

Kata Kunci:
Desain kelas; Desain kurikulum; Desain sekolah; Inovasi pembelajaran

History:
Received : 02/06/2024
Revised : 04/10/2024
Accepted : 18/10/2024
Published : 23/10/2024

Abstract

This article discusses the views of preservice biology teachers regarding the factors that dominate their motivation for innovative learning. A total of 152 preservice biology teachers were involved in this study. A correlation test was conducted to determine the relationship between curriculum design, school design, and class design with motivation to implement innovative learning. Data was collected using a questionnaire. The study results show that curriculum, school, and class design are collectively related to the motivation of preservice biology teachers to carry out innovative learning. Based on further analysis, the curriculum design factors significantly contributed to this relationship, while school and classroom design did not contribute significantly to this relationship. These results show that good curriculum design will support implementing innovative learning in the classroom. We recommend some things related to curriculum, school, and class design, the essence of which is the need to seek advice from students and teachers when renovating or building a school. Technology integration is also an important thing to include in the design plan. The government and related parties can use the results of this study in designing their schools or classrooms.

Abstrak. *Artikel ini membahas pandangan calon guru biologi mengenai faktor-faktor yang mendominasi motivasi mereka untuk pembelajaran inovatif. Sebanyak 152 calon guru biologi terlibat dalam penelitian ini. Data dikumpulkan menggunakan questionairre. Uji korelasi dilakukan untuk mengetahui hubungan antara curriculum design, school design, dan classroom design dengan motivasi untuk melaksanaan pembelajaran inovatif. Hasil penelitian menunjukkan bahwa desain kurikulum, sekolah, dan kelas secara kolektif berkaitan dengan motivasi guru biologi prajabatan untuk melaksanakan pembelajaran inovatif. Berdasarkan analisis lebih lanjut, faktor desain kurikulum berkontribusi signifikan terhadap hubungan ini, sementara desain sekolah dan kelas tidak berkontribusi signifikan terhadap hubungan ini. Hal ini menunjukkan bahwa desain kurikulum yang baik akan menunjang implementasi pembelajaran inovatif di kelas. Kami merekomendasikan beberapa hal yang berkaitan dengan kurikulum, sekolah, dan desain kelas, yang intinya adalah perlunya meminta saran dari siswa dan guru ketika merenovasi atau membangun sekolah. Integrasi teknologi juga merupakan hal yang penting untuk dimasukkan dalam rencana desain. Pemerintah dan pihak terkait dapat menggunakan hasil penelitian ini dalam merancang sekolah atau ruang kelasnya.*

A. Introduction

The progress of the world in the field of education has made a change from traditional classroom-centered learning with the teacher as the first instructor to student-centered learning. (OCED, 2015). The changes that occur aim to develop students' capabilities in careers in the 21st century (Dauer et al., 2021; Nahum et al., 2010; Page et al., 2023). In Indonesia, the Ministry of Education and Culture has reformed the learning curriculum from elementary to tertiary education to respond to the changes. Curriculum changes have also been accompanied by policy changes that support reforms in the education sector, such as improving infrastructure in education units. In pilot schools, classrooms are opened so teachers can learn from each other, increase student literacy by providing various digital environments, and so on. This action created an innovative learning environment that could be implemented in one or several classes (Cardno et al., 2018).

In recent years, the Indonesian government has increased programs and budgets in the education sector to equalize the quality of education, including improving infrastructure. There is a belief that the quality of infrastructure, including classrooms, will affect the quality of pedagogy (Carvalho & Yeoman, 2018; Montiel et al., 2019). The results of research that has been conducted to examine how classroom design influences pedagogy (Cox & Edwards, 2014; Kariippanon et al., 2018; Mulcahy et al., 2015; OCED, 2015). For example, a classroom close to the yard will increase teacher motivation for outdoor learning. However, other studies show weak relationships between classrooms and pedagogical change (Mulcahy et al., 2015). Pedagogical change, instead, is embedded in a variety of relationships and diverse practices. Studies on student learning environments do not only support contemporary learning needs and trends (Frelin & Grannäs, 2021; Gislason, 2018) but also play an important role in facilitating education reform (Cardellino & Woolner, 2020).

In other cases, for example, related to school buildings. Many new buildings are built by adopting a design that is more open and physically flexible, but based on several studies, and It turns out that this is not significant in improving student learning outcomes or improving teacher pedagogy (Ghaziani, 2020; Mulcahy et al., 2015; Rolfe et al., 2022). However, other studies have also shown that school design has different effects on the subjects students take (Lievore & Triventi, 2023; Tanner, 2009). These different results may be due to the lack of attention to the teacher's opinion in building design because each subject has different characteristics (Sudrajat et al., 2020; Susilo & Sudrajat, 2020).

So far, most recent research has focused on general subject contexts and used students as respondents (Barrett et al., 2015; Ghaziani, 2020; Mulcahy et al., 2015; Rolfe et al., 2022). This article provides a new perspective with preservice biology teachers as the respondents. Preservice biology teachers are important to explore because they have in-depth knowledge of their subject. In addition, they also have a unique view of motivation in the context of innovative learning. Biology teacher candidates also belong to different generations, so their views on how students learn are more or less the same. This study's specific objective was to determine preservice biology teachers' perceptions regarding the influence of design factors, including curriculum, class, and school design, on students' learning motivation. The results of this research are expected to be considered by the government and related parties in formulating policies for education reform.

B. Material and method

Participant and Data Collection

A total of 164 preservice biology teachers were involved in this survey. Due to incomplete information, 12 samples were excluded from this study. Thus, the final sample of our survey was 152 people (i.e., 18 males and 134 females). Participation in this survey is voluntary and anonymous. Data was collected by sending an online survey link to the National Research Group in a Google Form.

Furthermore, members of the Research Forum will share links to their universities. Respondents were also asked to forward questions to their colleagues. The questionnaire is designed to be completed in less than ten minutes. The questionnaire was chosen because it can obtain extensive data quickly, making it more effective (Pratama et al., 2024; Sudrajat et al., 2024).

Measures

Instructions and questions are translated into Indonesian following the procedures Sperber et al. (1994) outlined. All responses were made on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questions in the survey adopted the survey developed in the previous study by Scott-Webber et al. (2019). Because the questionnaire was a translation of an instrument developed by earlier researchers (Scott-Webber et al., 2019), we did not review the instrument's validity again. However, the instrument was tested for reliability to ensure the accuracy of the measurement (Ibrohim et al., 2022).

Curriculum Design

Sample items are "Curriculum design makes me want to work hard" and "I am still not facilitated even though I use the latest curriculum" (reverse coded) (6 items, $\alpha = 0.90$)

School Design

Sample items are "School design affects my ability to provide assistance and feedback to students" and "School design affects my ability to meet colleagues to study or collaborate" (4 items, α = 0.84)

Classroom Design

A sample item is "The design of the classroom affects my ability to move so I can be deeply involved in learning" (4 items, α = 0.82)

Motivation to Conduct Innovative Learning (MCIL)

Sample items are "When I become a teacher, I will be passionate about teaching" and "When I become a teacher, I will use innovative learning" (6 items, α = 0.88).

Data Analysis

We use a correlation test to determine the relationship between all variables. In addition, we also use ordinary least square regressions to determine the significance of the factors studied in influencing the motivation to conduct innovative learning.

C. Results and discussion

This study aims to explore the relationship between curriculum design, school design, and class design with the motivation to implement innovative learning. This article provides a new perspective because it explores the view of preservice biology teachers. The government and related parties can use the information in the results of this research to make policies related to the development and modernization of educational institutions. Similar previous studies have shown varying results (Barrett et al., 2015; Cox & Edwards, 2014; Ghaziani, 2020; Kariippanon et al., 2018; Mulcahy et al., 2015; Rolfe et al., 2022). The results of this study indicate that curriculum design, school design, and class design are related to the motivation of preservice biology teachers to carry out innovative learning. However, if analyzed further, curriculum design significantly influences this relationship. Meanwhile, school and class design had no significant effect on this relationship. The following is a more detailed description of the results of this study.

Table 1 shows the means, standard deviations (SD), and intercorrelations of all the variables used in this study. These results are consistent with previous studies, which show that curriculum, school, and class design are related to motivation to conduct innovative learning. Based on these results, the variables in the study are interrelated.

Table 1 Mean, SD, and intercorrelation between variables

	Mean	SD	Innovative learning
Curriculum design	4.460	.504	.546**
School design	4.143	.555	.266**
Classroom design	4.311	.554	.334**

We performed the ordinary least square regression test to examine these results in more detail, as shown in Table 2. Based on Table 2, the value of R = 0.05. Based on Chin (1998), the tested variable has a moderate correlation to the dependent variable. Therefore, it is concluded that the variables tested are related to the motivation to carry out innovative learning.

Table 2 Regression analysis results

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.555[a]	.308	.293	.37509

Furthermore, in Table 3, it is known that the regression equation obtained is as follows: MCIL = 2.250 + 0.436(Curriculum Design) + 0.044(School Design) + 0.58(Classroom Design). Seen in the Sig column. on the three variables (1) Curriculum Design = 0.000, (2) School Design = 0.496, and (3) Classroom Design = 0.396. Based on these results, only Sig. by Curriculum Design variable is less than 0.05, which means that only the Curriculum Design variable significantly influences motivation to conduct innovative learning. At the same time, other factors are not significant.

Table 3 Regression analysis results for each variable

Variable	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. error	Beta		
(Constant)	2.250	.315		7.148	.000
Curriculum Design	.436	.070	.492	6.246	.000
School Design	.044	.064	.054	.682	.496
Classroom Design	.058	.068	.072	.851	.396

Relationship between Curriculum Design and Motivation to Conduct Innovative Learning

The study results show that curriculum design contributes significantly to the motivation of preservice biology teachers to carry out innovative learning. The curriculum has a significant role in the learning process, both from the point of view of students and teachers (Cheng & Xu, 2011; Melo et al., 2022; Pykocz & Benites, 2023). Another opinion states that the curriculum is the essence of education (Galian & de Carvalho, 2021; Harrison et al., 2020; Júnior & Borges, 2021). Demands in the curriculum will be mandatory for a teacher to implement, including suggestions for innovative learning. Teachers will subconsciously follow instructions to implement innovative learning in their classrooms.

Studies on psychological aspects can explain this reason. Sometimes a person's self-view can be traced back to the interpersonal views that define those views (Baumeister, 1999). This statement can also be interpreted as a self-view about how someone evaluates you and your actions to respond to that (Bizzarri et al., 2023). This view also applies to the teacher's view of implementing what is contained in the curriculum. Instinctively, humans try to obtain an assessment that follows the majority (Baumeister et al., 2011); they subconsciously apply principles that others apply to their thinking. One of the preservice teachers said, "If the curriculum suggests using certain learning, as a teacher, I will try to do it in class."

We recommend several things related to things that need to be considered in designing the curriculum to create innovative learning, especially in science learning. The purpose of education, in general, is to improve students' thinking skills (Amin et al., 2020; Nasution et al., 2023; Zanden et al., 2020), of course, also applies to science learning (Hernawati et al., 2018; Ilma et al., 2022; Mitarlis et al., 2020; Ploj Virtič & Virtič, 2022). Science learning is highly compatible with developing students' thinking skills. The curriculum must be able to determine the science material that must be taught at every level of education. This is important because a comprehensive curriculum will ensure that students understand different science concepts holistically.

The curriculum must also follow the development of science (Keiny & Gorodetsky, 1996; Sari et al., 2019; Thuneberg et al., 2022). Science continues to develop and change over time. Relevant curriculum design will ensure the material is always up-to-date and reflects scientific developments (Twining et al., 2021). The curriculum must accommodate students' science process skills. A good curriculum must also pay attention to practical ways of teaching science. This means presenting the scientific process, including experimentation, observation, problem-solving, and reasoning so that students memorize facts and develop critical thinking skills and the scientific method. The curriculum must also accommodate the integration of technology into learning. A good curriculum design will consider the use of technology in science learning. Technology integration, such as computer simulations, interactive devices, and learning applications, can help increase students' understanding of complex science concepts. The curriculum must understand the needs of students. Curricula that focus on student learning and adapt to individual learning styles and needs can be more effective in achieving the desired learning outcomes. The curriculum must have a contextual nature. A good curriculum design will present science in a relevant and useful way for students' daily lives. This can increase their motivation and interest in learning science because they can see how science relates to the real world. With the right curriculum design, science learning can be directed more effectively, and students will be more engaged and inspired to explore and understand the scientific world better.

Relationship between School Design and Motivation to Conduct Innovative Learning

Even though school design is related to the motivation of preservice biology teachers to carry out innovative learning, separately, school design does not provide significant participation. These results follow the results of previous research studies. For example, research conducted by Blackmore et al. (2011) and Wells et al. (2018) shows that adapting the school's physical environment to technological innovations often has no impact and sometimes has a negative effect. For example, the introduction of open-plan learning spaces designed to enhance collaboration and flexibility has, in some cases, led to increased noise levels and distractions, making it harder for students to focus. The results of this research are also supported by subsequent studies that raise the same issue about the effect of school building on the educational process. Often, the physical aspect of school buildings ignores that schools are a complex system of interrelated social and cultural factors (Cardellino & Woolner, 2020). The development of school designs needs to involve teachers or students so that they can function optimally in improving the quality of student learning (Deppeler et al., 2021).

The school building design is more towards the accessibility of teachers and students (Niemi et al., 2022; Rolfe et al., 2022). Other factors also need to be considered because they affect student learning, for example, the dimensions of school facilities (Chingos, 2013), noise level (Fisher, 2001; Schneider, 2002), spatial (Wheldall & Lam, 1987), and the presence of natural elements in schools (Arbogast et al., 2009). One respondent explained, "Teachers need ergonomic access to reach every corner of the school and interact with students and other teachers. Intense interaction with both students and teachers can foster innovation in learning. Science learning requires a school design that makes it easy for students to access the surrounding environment. For example, there is a garden in front of the class, easily accessible laboratories, libraries, and others. One respondent said, "I think a school that is suitable for the subject of biology is a school that has an open environment such as parks, fields, and others," Another respondent said, "I think a school that is close to nature is suitable for studying biology."

We recommend several things so that school design can improve the quality of learning, especially in innovative and science learning. Science learning requires adequate laboratory space and facilities to conduct observations, experiments, and practicum. School design that pays attention to laboratory facilities' placement, equipment, and completeness can increase students' opportunities to participate in scientific exploration. A good science laboratory also ensures the safety and comfort of students during the experimental process. School design, especially classes, is expected to be interactive and inclusive to facilitate effective science learning. Classroom settings that allow interaction between teachers and students and collaboration between students can increase active participation and student involvement in the learning process. Interactive whiteboards, projectors, or other technologies can provide added value in presenting science material in an interesting and easy-to-understand way. The choice of colors, decorations, and placement of scientific posters or student work around school corridors can create an environment that stimulates interest and curiosity about science. School design must also pay attention to easy access to technology devices and internet access to assist teachers and students in finding information, conducting research, and using various applications to support science learning. Students and teachers must also have adequate access to reading resources or information. A complete library with a collection of science books, scientific journals, and digital learning resources can provide valuable support for science learning. School design also needs to consider space for extracurricular activities, such as science clubs, competitions, and exhibitions, to increase students' interest in and participation in science outside school hours.

Relationship between Classroom Design and Motivation to Conduct Innovative Learning

The findings in this study illustrate that although all factors simultaneously have a relationship with motivation to carry out innovative learning, class design does not have a significant relationship separately. The link between classroom design and student learning outcomes has been a focus of research in the last decade (Barrett et al., 2015; Frelin & Grannäs, 2021; Rands & Gansemer-Topf, 2017; Scott-Webber et al., 2019). Some of this research is driven by the belief that the inflexibility of traditional classroom designs cannot facilitate modern pedagogy and student-centered learning (OECD, 2021). With the latest thinking, classroom design is shifting towards providing flexible classroom layouts and open spaces and adapting the newest learning technologies (Davies et al., 2013; Frelin & Grannäs, 2021). Although other factors, such as temperature and air quality in the class (Smedje et al., 1997), classroom lighting conditions (Earthman, 2004), the distance between students (Weinstein, 1979), and furniture quality (Sommer & Olsen, 1980) also receive attention because it relates to the quality of student learning.

The classroom is the direct environment for students where the teaching and learning process takes place (Akomolafe & Adesua, 2015; Ibrohim et al., 2022; Martin, 2002). Open space allows students to move and collaborate freely. In addition, flexible tables and chairs allow teachers to change their learning designs. Students can also change their position to ask their friends so there are no mistakes or confusion in learning (Rands & Gansemer-Topf, 2017). One of the preservice teachers in the questionnaire said, "By using flexible desks/chairs, I'm sure I can organize the class according to what I think."

We recommend several things that must be considered in designing classroom settings so innovative learning can occur, especially in science learning. Science learning often involves experimentation and hands-on practice (Darling-hammond et al., 2020; Holstermann et al., 2010; Sudrajat et al., 2023). Adequate class design can provide the necessary facilities and equipment for science activities, such as laboratories, microscopes, measuring instruments, and practicum materials. These facilities and equipment allow students to experience first-hand the science concepts being taught and develop practical skills in science. In addition, science often involves observing natural phenomena and experiments involving observation. Good classroom design must consider a layout that allows all students to see the teacher's demonstration or experiment.

Class design must also be attractive and inspiring to stimulate students' imagination and creativity. For example, classroom walls decorated with scientific posters, infographics, or attractive science pictures can help students feel involved and interested in science learning. In addition, the class design must also pay attention to ergonomic factors, such as comfortable chairs and tables, as well as good lighting, which can create conditions that support comfortable learning. Science learning often involves collaboration and discussion between students. Classroom designs that accommodate spaces for collaboration, such as movable desks and group seating, can increase social interaction and discussion between students. The design must also consider using sophisticated and modern technologies, such as interactive projectors or digital whiteboards, which can enrich the science learning experience. The technology can display simulations, videos, or other multimedia materials to help students understand science concepts better.

D. Conclusion

Our research explains the relationship between curriculum, schools, classroom design, and motivation to implement innovative learning. We use the opinions of preservice biology teachers as a manifestation of the opinions of science teachers because they have the same characteristics. This study shows two main results: 1) curriculum, school design, and class design together have a relationship with motivation to implement innovative biology teacher candidates; 2) separately, the curriculum design makes a significant contribution to this relationship, while other factors (school design and classroom design) do not contribute a significant relationship. The results of this study must be reconfirmed by conducting case studies on students and teachers with different school designs. Preservice teachers' views can be considered by the government when formulating policies regarding the construction or renovation of schools. Preservice teachers have a more visionary view because their interaction with technology is more massive than the previous generation. The results of this study provide a new perspective that in training prospective biology teachers, prospective biology teachers must be trained to utilize existing conditions in schools to implement innovative learning. We suggest various aspects regarding curriculum, school infrastructure, and classroom design, emphasizing the importance of involving both students and teachers in the process of school renovation or construction. Incorporating technology into the design plans is also crucial. The government and other relevant stakeholders can apply the insights from this research in developing school and classroom designs.

E. References

Akomolafe, C. O., & Adesua, V. O. (2015). The classroom environment: A major motivating factor towards high academic performance of senior secondary school students in South West Nigeria. *Journal of Education and Practice*, *6*(34), 17–21. Retrieved from https://eric.ed.gov/?id=EJ1086098

Amin, A. M., Corebima, A. D., Zubaidah, S., & Mahanal, S. (2020). The correlation between metacognitive skills and critical thinking skills at the implementation of four different learning strategies in animal physiology lectures. *European Journal of Educational Research*, *9*(1), 143–163. DOI: https://doi.org/10.12973/eu-jer.9.1.143

Arbogast, K. L., Kane, B. C. P., Kirwan, J. L., & Hertel, B. R. (2009). Vegetation and outdoor recess time at elementary schools: What are the connections? *Journal of Environmental Psychology*, *29*(4), 450–456. DOI: https://doi.org/https://doi.org/10.1016/j.jenvp.2009.03.002

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results ofaholistic, multi-level analysis. *Building and Environment*, *89*, 118–133. DOI: https://doi.org/10.1016/j.buildenv.2015.02.013

Baumeister, R. F. (1999). The self in social psychology. In R. F. Baumeister (Ed.), *The self in social psychology.* Psychology Press.

Baumeister, R. F., Masicampo, E. J., & DeWall, C. N. (2011). Arguing, reasoning, and the interpersonal (cultural) functions of human consciousness. *Behavioral and Brain Sciences*, *34*(2), 74. DOI: https://doi.org/10.1017/S0140525X10002785

Bizzarri, F., Giuliani, A., & Mocenni, C. (2023). Decision making in networks: A model of awareness raising. *Information (Switzerland)*, *14*(2), 1-14. DOI: https://doi.org/10.3390/info14020072

Blackmore, J., Bateman, D., Loughlin, J., O'Mara, J., & Aranda, G. (2011). *Research into the connection between built learning spaces and student outcomes*. Retrieved from https://dro.deakin.edu.au/articles/report/Research_into_the_connection_between_built_learning_spaces_and_student_outcomes/21003409

Cardellino, P., & Woolner, P. (2020). Designing for transformation–a case study of open learning spaces and educational change. *Pedagogy, Culture and Society*, *28*(3), 383–402. DOI: https://doi.org/10.1080/14681366.2019.1649297

Cardno, C., Tolmie, E., & Howse, J. (2018). New spaces – new pedagogies: Implementing personalised learning in primary school innovative learning environments. *Journal of Educational Leadership, Policy and Practice*, *33*(1), 111–124. DOI: https://doi.org/doi:10.21307/jelpp-2017-010

Carvalho, L., & Yeoman, P. (2018). Framing learning entanglement in innovative learning spaces: Connecting theory, design and practice. *British Educational Research Journal*, *44*(6), 1120–1137. DOI: https://doi.org/https://doi.org/10.1002/berj.3483

Cheng, L., & Xu, N. (2011). The complexity of Chinese pedagogic discourse. *Journal of Curriculum Studies*, *43*(5), 606–614. DOI: https://doi.org/10.1080/00220272.2011.595430

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. In *Modern Methods for Business Research*. Retrieved from http://books.google.com.sg/books?hl=en&lr=&id=EDZ5AgAAQBAJ&oi=fnd&pg=PA295&dq=chin+1998+PLS&ots=47qB7ro0np&sig=rihQBibvT6S-Lsj1H9txe9dX6Zk#v=onepage&q&f=false

Chingos, M. M. (2013). Class size and student outcomes: Research and policy implications. *Journal of Policy Analysis and Management*, *32*(2), 411–438. Retrieved from http://www.jstor.org/stable/42001539

Cox, P., & Edwards, D. (2014). *Restructuring teaching and learning in open-plan schools BT - Adapting to teaching and learning in open-plan schools* (V. Prain, P. Cox, C. Deed, D. Edwards, C. Farrelly, M. Keeffe, V. Lovejoy, L. Mow, P. Sellings, B. Waldrip, & Z. Yager (eds.), (pp. 61–78). SensePublishers. DOI: https://doi.org/10.1007/978-94-6209-824-4_4

Darling-hammond, L., Flook, L., Cook-harvey, C., Barron, B., Flook, L., Cook-harvey, C., Darling-hammond, L., Flook, L., Cook-harvey, C., & Barron, B. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. DOI: https://doi.org/10.1080/10888691.2018.1537791

Dauer, J., Mayes, R., Rittschof, K., & Gallant, B. (2021). Assessing quantitative modelling practices, metamodelling, and capability confidence of biology undergraduate students. *International Journal of Science Education*, *43*(10), 1685–1707. DOI: https://doi.org/10.1080/09500693.2021.1928325

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education-A systematic literature review. *Thinking Skills and Creativity*, *8*(1), 80–91. DOI: https://doi.org/10.1016/j.tsc.2012.07.004

Deppeler, J., Corrigan, D., Macaulay, L., & Aikens, K. (2021). Innovation and risk in an innovative learning environment: A Private Public Partnership in Australia. *European Educational Research Journal*, *21*(4), 602–626. https://doi.org/10.1177/14749041211030400

Earthman, G. I. (2004). *Prioritization of 31 citeria for school building adequacy*. United States: American Civil Liberties Union Foundation of Maryland Baltimore.

Fisher, K. (2001). *Schooling issues digest building better outcomes : The impact of school infrastructure on student outcomes and behaviour.* Canberra: Australian Dept. of Employment, Education, Training and Youth Affairs. Retrieved from http://www.detya.gov.au/schools/publications/2001/index.htm.

Frelin, A., & Grannäs, J. (2021). Designing and building robust innovative learning environments. *Buildings*, *11*(8), 345. DOI: https://doi.org/10.3390/buildings11080345

Galian, C. V. A., & de Carvalho, M. B. (2021). Between curricula reforms and pedagogical practices: Ursula Hoadley and the “pedagogy in poverty.” *Educacao e Pesquisa*, *47*(e202147002002), 1-10. DOI: https://doi.org/10.1590/S1678-4634202147002002

Ghaziani, R. (2020). Primary school design: Co-creation with children. *Archnet-IJAR*, *15*(2), 285–299. DOI: https://doi.org/10.1108/ARCH-07-2020-0132

Gislason, N. (2018). *12 the whole school: Planning and evaluating innovative middle and secondary schools,* (pp. 187–201), Brill. DOI: https://doi.org/10.1163/9789004379664_012

Harrison, T., Burn, E., & Moller, F. (2020). Teaching character; cultivating virtue perception and virtue reasoning through the curriculum. *Educational Review*, *72*(5), 617–634. DOI: https://doi.org/10.1080/00131911.2018.1538937

Hernawati, D., Amin, M., Irawati, M., Indriwati, S., & Aziz, M. (2018). Integration of project activity to enhance the scientific process skill and self-efficacy in zoology of vertebrate teaching and learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(6), 2475–2485. DOI: https://doi.org/10.29333/ejmste/89940

Holstermann, N., Grube, D., & Bögeholz, S. (2010). Hands-on activities and their influence on students’ interest. *Research in Science Education*, *40*, 743–757. DOI: https://doi.org/10.1007/s11165-009-9142-0

Ibrohim, I., Purwaningsih, E., Munzil, M., Hidayanto, E., Sudrajat, A. K., Saefi, M., & Hassan, Z. bin. (2022). Possible links between Indonesian science teacher’s TPACK perception and demographic factors: Self-reported survey. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(9), em2146. DOI: https://doi.org/10.29333/ejmste/12282

Ilma, S., Al-Muhdhar, M. H. I., Rohman, F., & Sari, M. S. (2022). Promoting students’ metacognitive awareness and cognitive learning outcomes in science education. *International Journal of Evaluation and Research in Education*, *11*(1), 20–30. DOI: https://doi.org/10.11591/ijere.v11i1.22083

Júnior, N. E. S., & Borges, L. F. F. (2021). Curriculum policies for vocational education and teaching work. *Educacao e Pesquisa*, *47*(e222664), 1-17. DOI: https://doi.org/10.1590/S1678-4634202147222664

Kariippanon, K. E., Cliff, D. P., Lancaster, S. L., Okely, A. D., & Parrish, A.-M. (2018). Perceived interplay between flexible learning spaces and teaching, learning and student wellbeing. *Learning Environments Research*, *21*(3), 301–320. DOI: https://doi.org/10.1007/s10984-017-9254-9

Keiny, S., & Gorodetsky, M. (1996). Curriculum development in science, technology and society (STS) as a means of teachers' conceptual change. *Educational Action Research*, *4*(2), 185-195. DOI: https://doi.org/10.1080/0965079960040203

Lievore, I., & Triventi, M. (2023). Do teacher and classroom characteristics affect the way in which girls and boys are graded? *British Journal of Sociology of Education*, *44*(1), 97–122. DOI: https://doi.org/10.1080/01425692.2022.2122942

Martin, S. H. (2002). The classroom environment and its effects on the practice of teachers. *Journal of Environmental Psychology*, *22*(1), 139–156. DOI: https://doi.org/https://doi.org/10.1006/jevp.2001.0239

Melo, M. J. C. de, Almeida, L. A. A. de, & Leite, C. (2022). Currículos de formação de professores: o poder de agência em questão. *Educacao e Pesquisa*, *48*(e247432), 1-20. DOI: https://doi.org/10.1590/S1678-4634202248247432por

Mitarlis, M., Ibnu, S., Rahayu, S., & Sutrisno. (2020). The effectiveness of new inquiry-based learning (NIBL) for improving multiple higher-order thinking skills (M-HOTS) of Prospective chemistry teachers. *European Journal of Educational Research*, *9*(3), 1309–1325. DOI: https://doi.org/10.12973/eu-jer.9.3.1309

Montiel, I., Mayoral, A. M., Navarro Pedreño, J., &

Maiques, S. (2019). Acoustic comfort in learning spaces: Moving towards sustainable development goals. *Sustainability*, *11*(13), 3573. DOI: http://dx.doi.org/10.3390/su11133573

Mulcahy, D., Cleveland, B., & Aberton, H. (2015). Learning spaces and pedagogic change: envisioned, enacted and experienced. *Pedagogy, Culture and Society*, *23*(4), 575–595. DOI: https://doi.org/10.1080/14681366.2015.1055128

Nahum, T. L, Ben-Chaim, D., Azaiza, I., Herskovitz, O., & Zoller, U. (2010). Does STES-oriented science education promote 10th-grade students' decision-making capability? *International Journal of Science Education*, *32*(10), 1315–1336. DOI: https://doi.org/10.1080/09500690903042533

Nasution, N. E. A., Al Muhdhar, M. H. I., Sari, M. S., & Balqis. (2023). Relationship between critical and creative thinking skills and learning achievement in biology with reference to educational level and gender. *Journal of Turkish Science Education*, *20*(1), 66–83. DOI: https://doi.org/10.36681/tused.2023.005

Niemi, K., Minkkinen, J., & Poikkeus, A. M. (2024). Opening up learning environments: liking school among students in reformed learning spaces. *Educational Review*, *76*(5), 1191-1208. DOI: https://doi.org/10.1080/00131911.2022.2098927

OCED. (2015). Schooling redesigned. In *OECD Publishing*. OECD. DOI: https://doi.org/10.1787/9789264245914-en

OECD. (2021). *Curriculum (re)design: A series of thematic reports from the OECD Education 2030 project. Overview Brochure* (Vol. 3). Retrieved from https://www.oecd.org/education/2030-project/curriculum-analysis/

Page, A., Anderson, J., & Charteris, J. (2023). Teachers working with students with high and very high needs and their perceptions of Innovative Learning Environments. *Asia Pacific Journal of Education*, *43*(3), 895-911. DOI: https://doi.org/10.1080/02188791.2023.2177614

Pratama, A. T., Sudrajat, A. K., Anazifa, R. D., & Kurniawati, A. (2024). Factors that influence global literacy: what is the most dominant? *International Journal of Evaluation and Research in Education*, *13*(5), 2989–2995. DOI: https://doi.org/10.11591/ijere.v13i5.28903

Pykocz, D., & Benites, L. C. (2023). A construção discursiva da realidade na Base Nacional Comum Curricular. *Educacao e Pesquisa*, *49*(e250430), 1-19. DOI: https://doi.org/10.1590/S1678-4634202349250430por

Rands, M. L., & Gansemer-Topf, A. M. (2017). The room itself is active: How classroom design impacts student engagement. *Journal of Learning Spaces*, *6*(1), 26–33. Retrieved from https://eric.ed.gov/?id=EJ1152568

Rolfe, A., Franz, J., & Bridge, A. (2022). The combined impact of school design and procurement on student wellbeing and educational outcomes. *Facilities*, *40*(7–8), 533–550. DOI: https://doi.org/10.1108/F-08-2021-0071

Sari, M. S., Sunarmi, S., Sulasmi, E. S., Wicaksono, R. S., & Sudrajat, A. K. (2019). Information literacy skill: An alternative to support biology student's learning outcomes. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *5*(3), 451–458. DOI: https://doi.org/10.22219/jpbi.v5i3.8768

Schneider, M. (2002). Do school facilities affect academic outcomes? In *National Clearinghouse for Educational Facilities, Washington, DC* (pp. 1-26). Retrieved from https://files.eric.ed.gov/fulltext/ED470979.pdf

Scott-Webber, L., Konyndyk, R., & Denison, M. (2019). POE: Understanding innovative learning places and their impact on student academic engagement—index 6–8 'Alpha' survey developments. *Journal of Education and Learning*, *8*(5), 31-56. DOI: https://doi.org/10.5539/jel.v8n5p31

Smedje, G., Norback, D., & Edling, C. (1997). Asthma among secondary schoolchildren in relation to the school environment. *Clinical & Experimental Allergy*, *27*(11), 1270–1278. DOI: https://doi.org/10.1111/j.1365-2222.1997.tb01171.x

Sommer, R., & Olsen, H. (1980). The soft classroom. *Environment and Behavior*, *12*(1), 3–16. DOI: https://doi.org/10.1177/0013916580121001

Sudrajat, A. K., Andriningrum, H., Supartinah, S., & Anggrella, D. P. (2023). Accelerating pre-service elementary school teacher students' problem-solving skills through online case study discussion. *International Journal of Innovation and Learning*, *34*(4), 398–413. DOI: https://doi.org/10.1504/IJIL.2023.134749

Sudrajat, A. K., Ibrohim, & Susilo, H. (2024). Demographic factors affecting technological pedagogical content knowledge in Generation-Z preservice biology teachers. *International Journal of Evaluation and Research in Education*, *13*(6), 3796–3805. DOI: https://doi.org/10.11591/ijere.v13i6.30355

Sudrajat, A. K., Susilo, H., & Rohman, F. (2020, April). Student perspective on the importance of developing critical thinking and collaboration skills for prospective teacher students. In *AIP Conference Proceedings* (Vol. 2215, No. 1). AIP Publishing. DOI: https://doi.org/10.1063/5.0000558

Susilo, H., & Sudrajat, A. K. (2020, June). STEM learning and its barrier in schools: The case of biology teachers in Malang City. In *Journal of Physics: Conference Series* (Vol. 1563, No. 1, p. 012042). IOP Publishing. DOI: https://doi.org/10.1088/1742-6596/1563/1/012042

Tanner, C. K. (2009). Effects of school design on student outcomes. *Journal of Educational Administration*, *47*(3), 381–399. DOI: https://

doi.org/10.1108/09578230910955809

Thuneberg, H., Salmi, H., Vainikainen, M., Hienonen, N., & Hautamäki, J. (2022). New curriculum towards Big ideas in science education. *Teachers and Teaching*, *28*(4), 440–460. DOI: https://doi.org/10.1080/13540602.2022.2062739

Twining, P., Butler, D., Fisser, P., Leahy, M., Shelton, C., Forget, N., & Michel, D. (2021). Developing a quality curriculum in a technological era. *Educational Technology Research and Development*, *69*(4), 2285–2308. DOI: https://doi.org/10.1007/s11423-020-09857-3

Virtič, M. P. (2022). Teaching science & technology: components of scientific literacy and insight into the steps of research. *International Journal of Science Education*, *44*(12), 1916–1931. DOI: https://doi.org/10.1080/09500693.2022.2105414

Weinstein, C. S. (1979). The physical environment of the school: A review of the research. *Review of Educational Research*, *49*(4), 577–610. DOI: https://doi.org/10.3102/00346543049004577

Wells, A., Jackson, M., & Benade, L. (2018). *Modern learning environments: embodiment of a disjunctive encounter BT - Transforming education: Design & governance in global contexts* (L. Benade & M. Jackson (eds.); pp. 3–17). Springer Singapore. DOI: https://doi.org/10.1007/978-981-10-5678-9_1

Wheldall, K., & Lam, Y. Y. (1987). Rows versus tables. II. The effects of two classroom seating arrangements on classroom disruption rate, on-task behaviour and teacher behaviour in three special school classes. *Educational Psychology*, *7*(4), 303–312. DOI: https://doi.org/10.1080/0144341870070405

Zanden, P. J. A. C. Van Der, Denessen, E., Cillessen, A. H. N., Meijer, P. C., Zanden, P. J. A. C. Van Der, Denessen, E., & Cillessen, A. H. N. (2020). Fostering critical thinking skills in secondary education to prepare students for university : Teacher perceptions and practices. *Research in Post-Compulsory Education*, *25*(4), 394–419. DOI: https://doi.org/10.1080/13596748.2020.1846313