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DEVELOPING DIGITAL ACADEMIC SUPERVISION TO IMPROVE TEACHERS' ABILITY TO IMPLEMENT DEEP LEARNING

Sri Warningsih [1] Rosmala Dewi [2] Arif Rahman [3]
Educational Administration Study Program, State University of Medan, Medan, Indonesia
E-mail: sriwarningsih47@guru.sma.belajar.id [1] ros_dw@unimed.ac.id [2] arifrahman@unimed.ac.id [3]
*Author Correspondence

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Abstract

This study aims to develop digital academic supervision for school principals to support the improvement of teachers' abilities in implementing the Deep Learning approach at the Az-Zahro Foundation, Sendang Rejo, Langkat Regency. The study used a research and development method with a 4D model that includes define, design, develop, and disseminate. The research subjects consisted of 30 teachers as quantitative respondents and two principals as qualitative informants. Data were collected through observation, interviews, questionnaires, and documentation. Product feasibility was assessed by experts, while effectiveness was analyzed through a comparison of pretest and posttest scores, N-Gain, and paired samples t-test. The results showed that the product, a web-based application, has six characteristics: data-driven, flexible, reflective, oriented towards deep learning, sustainable, and collaborative. Product validation obtained a score of 81.88% with a feasible category, while user responses reached an average of 4.06 with a good category. The average teacher ability score increased from 72.77 to 91.70. The N-Gain of 0.4365 is in the moderate category, while the effectiveness percentage of 43.65% is in the less effective category. The t-test results showed a significant difference ($t = -12.469$; $p < 0.001$). These findings indicate that the system is suitable for use as a supervisory support tool, but improving teacher skills still requires ongoing mentoring.

Keywords: digital academic supervision; Deep Learning; teacher competence; web-based system

INTRODUCTION

The quality of learning is a crucial element in achieving educational goals. Changing student characteristics, scientific developments, and the demands of 21st-century competencies encourage schools to develop learning processes that are not solely focused on delivering material. Learning needs to provide opportunities for students to deeply understand concepts, connect knowledge to real-life situations, develop higher-order thinking skills, and build character and social skills. These needs place teachers as the primary determinant of the quality of classroom learning experiences.

The Deep Learning approach in the educational context emphasizes a meaningful, conscious, and enjoyable learning process through the principles of Meaningful Learning, Mindful Learning, and Joyful Learning. Meaningful Learning directs teachers to connect material with students' prior knowledge, experiences, and life contexts. Mindful Learning emphasizes students' awareness in participating in the learning process, managing their thoughts, and reflecting. Joyful Learning encourages the creation of a positive learning atmosphere through engaging, interactive activities that are tailored to students' needs. The application of these three principles needs to be accompanied by the development of the 6C dimensions: Character, Citizenship, Collaboration, Communication, Creativity, and Critical Thinking (Wijaya et al., 2025; Mutmainnah et al., 2025).

Implementing this approach requires teachers to have the skills to plan learning objectives, select strategies and media, manage classroom interactions, and develop assessments that measure student understanding and skills. These skills are not always developed through one-off training activities. Teachers require ongoing, needs-based coaching, accompanied by feedback on their learning practices. Principals are strategically positioned to ensure this coaching is effective through academic supervision.

Academic supervision is a professional support process aimed at improving the quality of learning and developing teacher competencies. Its implementation should include supervision planning, observing the learning process, discussing the results, providing feedback, reflecting on it, and following up. Supervision oriented toward

professional development positions the principal not only as an assessor but also as a mentor who helps teachers recognize strengths, identify areas for improvement, and design learning development steps. The developmental supervision approach emphasizes the importance of adapting the form of guidance to the teacher's needs and level of professional development (Glickman, 2013).

Conventional supervision management can face challenges when observation data, learning documents, and follow-up notes are stored separately. Tracking supervision history requires reviewing previous documents, while monitoring teacher progress cannot be done quickly and in an integrated manner. The use of digital technology can support recording, archiving, access to assessment results, and follow-up communication. Research on digital-based academic supervision shows that technology can be used to assist in managing the supervision process and support teacher professional development (Danial et al., 2022; Qamaruzzaman et al., 2024). However, digital systems should be positioned as a supporting tool, not a substitute for classroom observation and professional dialogue between principals and teachers.

These issues were identified during the implementation of academic supervision at the Az-Zahro Foundation in Sendang Rejo, Binjai District, Langkat Regency. Based on initial interviews with the principals of the Madrasah Ibtidaiyah and Madrasah Tsanawiyah schools in September 2025, supervision activities were still conducted through face-to-face meetings, while learning observations were recorded manually. Supervision documents were not yet stored in a single, integrated system, and tracking teacher progress still required review of previous records. The foundation also expressed the need for a system that could facilitate more structured documentation of supervision results and monitoring of teacher progress.

Problems are not only related to the administrative management of supervision, but also to teachers' ability to implement the Deep Learning approach. The results of supervision and learning observations of 30 teachers in August, September, and October 2025 showed that teacher abilities were not evenly distributed. The percentage of teachers demonstrating the ability to implement Meaningful Learning was 51%, Mindful Learning 61%, and Joyful Learning 45%. In the 6C dimension, the ability to develop Communication only reached 33%, while Critical Thinking 45% and Collaboration 52%. The ability to implement project-based learning was also at 45%. These findings indicate the need for coaching that specifically directs supervisory practices to indicators of deep learning, not just checking administrative completeness.

Based on these conditions, this study developed a web-based digital academic supervision that integrates teacher data, assessment instruments, observation recording, feedback, teacher reflection, follow-up monitoring, and supervision history storage. The product is designed for use by administrators, principals, and teachers through different access rights. Development was carried out using the 4D model: Define, Design, Development, and Disseminate. This study aims to identify the characteristics of digital academic supervision that suit school needs, determine the product's feasibility based on expert assessments and user responses, and analyze changes in teachers' abilities in using the Deep Learning approach after the product's implementation.

LITERATURE REVIEW

Deep Learning in learning

Deep Learning in an educational context is a learning approach that emphasizes in-depth conceptual understanding and the application of knowledge in real-world contexts. Learning does not stop at mastering information, but provides space for students to explore, analyze, connect, and reflect on knowledge. The three main principles used are Meaningful Learning, Mindful Learning, and Joyful Learning. Meaningful Learning connects material with students' prior experiences and knowledge; Mindful Learning fosters awareness and reflection in the learning process; while Joyful Learning creates a positive learning environment that supports student engagement (Mutmainnah et al., 2025).

This approach also focuses on developing the 6C competencies: character, citizenship, collaboration, communication, creativity, and critical thinking. Teachers play a key role in designing contextual, authentic, competency-based, project-based, or problem-solving learning experiences. Therefore , teachers' ability to implement Deep Learning needs to be assessed through lesson planning, implementation, and evaluation, which provide opportunities for students to be active and reflective.

Digital academic supervision

Academic supervision is professional assistance provided to teachers to improve the quality of the learning process. Supervisory activities include planning, observing learning, providing feedback, reflecting, and following up. Effective supervision requires a professional relationship between the supervisor and the teacher so that

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observations can be used as a basis for learning improvement, not simply as an administrative assessment (Glickman, 2013).

Digital academic supervision utilizes information technology to support recording, management, feedback delivery, and follow-up monitoring. Digital systems can help centrally store supervision history and facilitate user access to assessment results. However, the use of technology does not eliminate the need for direct interaction, as learning observations, professional dialogue, and coaching still require communication between the principal and teachers. This research combines web-based system support with a reflective and collaborative supervision cycle.

Research gaps

Studies on digital supervision and in-depth learning have discussed the use of technology in supervision management and strengthening learning approaches. However, the need to develop a system that specifically integrates supervision instruments with indicators of Meaningful Learning, Mindful Learning, Joyful Learning, and the 6C competencies in the context of madrasah foundations remains to be clarified through product development and user testing. This research addresses this need by developing a digital academic supervision application that was tested for feasibility and teacher competency changes before and after implementation.

METHOD

The research used a research and development (R&D) method with a 4D model consisting of Define, Design, Development, and Disseminate. The research was conducted at the Az-Zahro Foundation, Sendang Rejo, Binjai District, Langkat Regency. The needs analysis phase took place from July to October 2025, design in October 2025, development and testing in November to December 2025, and dissemination in January 2026.

The quantitative research subjects consisted of 30 teachers, 20 from elementary and 10 from junior high schools. Qualitative data were obtained through interviews with two principals (MI and MTs) and relevant sources within the foundation. Primary data were collected through observation, interviews, questionnaires, and documentation. Secondary data came from supervisory documents and relevant library sources.

The Define stage includes observations of supervision conditions, interviews, questionnaire distribution, documentation, SWOT analysis, needs analysis, and literature review. The Design stage includes the development of system flows, interface designs, supervision instruments, and web-based application prototypes. The Development stage includes system development, instrument and product validation by experts, revisions, user trials, and effectiveness testing. The Disseminate stage is carried out through socialization, system usage training, mentoring for one supervision cycle, and handover of the system and user manual to the foundation.

The product was developed for three user groups: administrators, principals, and teachers. Key features include teacher data management, supervision assessment instruments, observation recording, principal feedback, teacher reflection, follow-up monitoring, and supervision history storage. The supervision cycle includes pre-observation, observation, post-observation, and follow-up. The teacher competency instrument incorporates in-depth learning principles and the 6C competency indicators.

Feasibility analysis was conducted based on the percentage of expert validation results. User responses were analyzed using the average questionnaire score. Effectiveness was analyzed using a one-group pretest-posttest design on 30 teachers. Score changes were analyzed using N-Gain and paired samples t-test. Normality testing was conducted using Shapiro-Wilk. N-Gain interpretation used the categories low ($g < 0.30$), medium ($0.30 \leq g < 0.70$), and high ($g \geq 0.70$). Statistical results were reported as listed in the research data processing results.

RESULTS AND DISCUSSION

Initial conditions and product characteristics

The needs analysis revealed that prior to the development, academic supervision was still conducted conventionally. Learning observations were conducted through face-to-face meetings, while supervision results were recorded and stored manually. This situation resulted in incomplete documentation and impractical tracking of previous supervision results. The primary need identified was a system that could integrate supervision data, provide access to assessment results, and support follow-up monitoring.

Initial observations of 30 teachers revealed varying abilities in implementing Deep Learning indicators. Regarding learning principles, teachers' ability to implement Meaningful Learning was recorded at around 51%, Mindful Learning at 61%, and Joyful Learning at 45%. Regarding learning characteristics, competency-based learning reached around 48%, contextual and authentic learning at 52%, project-based learning at 45%, and reflective learning at 64%. In the 6C dimension, Character and Citizenship indicators each reached around 52%, Collaboration at 52%,

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Communication at 33%, Creativity at 58%, and Critical Thinking at 45%. These data indicate that aspects of communication, critical thinking, and project-based learning require attention in teacher development.

Table 1. Results of initial observations of teachers' ability to apply Deep Learning

Indicator	Percentage
Meaningful Learning	51%
Mindful Learning	61%
Joyful Learning	45%
Competency-based learning	48%
Contextual and authentic	52%
Project based	45%
Reflective	64%
Character	52%
Citizenship	52%
Collaboration	52%
Communication	33%
Creativity	58%
Critical Thinking	45%

The developed product has six characteristics: data-driven, flexible, reflective, deep learning-oriented, sustainable, and collaborative. The data-driven characteristic is realized through digital storage of supervision results. Flexibility allows users to access information without always meeting in person. The reflective nature is evident in the series of pre-observations, observations, post-observations, and follow-up. The Deep Learning orientation is incorporated into the supervision instrument through the principles of Meaningful Learning, Mindful Learning, Joyful Learning, and the 6C dimensions. The sustainable and collaborative nature is realized through feedback, progress monitoring, and a space for sharing learning practices.

Product feasibility and user response

The instrument validation results by three validators yielded a feasibility percentage of 88.02%, categorized as feasible. The aspects of item suitability to indicators and item relevance to variables received the highest scores at 91.67%, while wording clarity received a score of 83.33%. These results indicate that the instrument met its measurement objectives, although the wording of several items still needed refinement.

Product validation by two experts resulted in a feasibility percentage of 81.88%, categorized as feasible. The product's suitability for supervision requirements received the highest score of 90.63%, while data security received the lowest score of 71.88%. Validator input related to access rights settings, navigation consistency, data backup, and account verification. Revisions were made through user role settings, standardization of icons and layouts, the addition of periodic data backups, and account validation.

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Table 2. Validation results and user responses

Component	Results	Category
Instrument validation (3 validators)	88.02%	Worthy
Product validation (2 experts)	81.88%	Worthy
Product conformity to supervision needs	90.63%	The highest aspect
Data security	71.88%	Quite decent
Average user response	4.06	Good
Net Benefits	4.25	Very good
Service Quality	3.88	Good

The limited trial achieved an average user response of 4.06, categorized as good. The Net Benefits indicator received the highest score of 4.25, indicating that the system's primary benefits were perceived in supervision documentation, access to assessment results, and follow-up. Service Quality received the lowest score of 3.88, although still in the good category. These findings indicate that technical support, user manuals, and problem-solving still need improvement.

Effectiveness on teacher abilities

Measurement results for 30 teachers showed an increase in the average proficiency score from 72.77 in the pretest to 91.70 in the posttest. The average difference of 18.93 points indicates an improvement after the implementation of digital academic supervision. The standard deviation decreased from 15.03 to 8.15, indicating a more homogeneous distribution of posttest scores compared to pretest scores.

Table 3. Comparison of pretest and posttest scores

Measurement	N	Average	Standard deviation
Pretest	30	72.77	15.03
Posttest	30	91.70	8.15

The N-Gain analysis results showed an average value of 0.4365 with a standard deviation of 0.09509, a minimum value of 0.21, and a maximum of 0.64. A total of 27 teachers (90.0%) were in the moderate improvement category and three teachers (10.0%) were in the low category. No teachers reached the high category. Based on the N-Gain category, the overall improvement in teacher abilities was moderate.

Table 4. Distribution of N-Gain categories

Category	Number of teachers	Percentage
Tall	0	0.0%
Currently	27	90.0%
Low	3	10.0%
Total	30	100%

A paired samples t-test showed a significant difference between pretest and posttest scores ($t = -12.469$; $df = 29$; $p < 0.001$). The Cohen's dz effect size was reported at 2.28. These results indicate that the change in scores before and after product implementation was statistically significant. However, the N-Gain percentage of 43.65% is in the less effective category based on the effectiveness percentage criteria used in the study. Thus, moderate improvement and statistical significance cannot be equated with achieving a high effectiveness category.

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These differences are important in interpreting development results. Expert validation indicates the product is feasible, and user responses indicate good acceptance. However, teacher performance improvement remains limited to the moderate category. The relatively short implementation duration, the need for repeated practice, and the need for more intensive feedback should be considered in future development. Teachers with high initial scores also have more limited room for improvement.

Implications and limitations

A digital academic supervision system can be used to support documentation and follow-up of teacher coaching. Integrating Deep Learning indicators into supervision tools helps principals focus coaching on the quality of the learning process, not just administrative completeness. System use still needs to be combined with classroom observations and direct dialogue to ensure feedback is contextual and tailored to teachers' needs.

This study is limited by its subject coverage from a single foundation and the use of a one-group pretest-posttest design without a comparison group. Therefore, the improvement results need to be interpreted within the context of implementation at the Az-Zahro Foundation and cannot be broadly generalized. Internet network limitations, the need to simplify user instructions, and strengthening data security are also aspects that require attention in further implementation.

The relationship between initial requirements and system design

Initial findings revealed two interrelated needs: the administrative need to manage supervision documents and the pedagogical need to develop teachers' ability to implement in-depth learning. Both served as the basis for product development. Digital data management addressed the challenges of document recording and tracking, while instruments incorporating the principles of Meaningful Learning, Mindful Learning, Joyful Learning, and the 6Cs directed the supervision process toward learning aspects that needed improvement. Thus, the system design not only shifted the recording medium from paper to digital but also clarified the focus of the principal's coaching.

The meaning of the six characteristics of digital academic supervision

Data-driven characteristics are demonstrated through the storage of assessment results and supervision history within the system, allowing principals to track teacher progress based on available documentation. Flexible characteristics are evident in the system's access by administrators, principals, and teachers, depending on their roles. This flexibility allows users to obtain supervision information without having to meet frequently for administrative matters, but it does not eliminate the need for in-person meetings when discussing instructional practices.

Reflective characteristics are demonstrated through a series of pre-observations, observations, post-observations, and follow-up. This series provides space for teachers to present lesson plans, receive observation results, discuss aspects that have gone well, and identify improvements that need to be made. The orientation toward Deep Learning is demonstrated through assessment indicators that observe the implementation of meaningful, conscious, and enjoyable learning and the development of the 6C competencies. Sustainable and collaborative characteristics are demonstrated through record keeping, follow-up monitoring, feedback, and opportunities to share learning practices.

These six characteristics demonstrate that the success of digital supervision is not solely measured by the availability of an application. The system needs to link observation data with reflection and corrective action. If assessment results are simply stored without being discussed with teachers, the coaching function is not fully implemented. Therefore, the principal remains crucial in interpreting assessment results, determining mentoring priorities, and monitoring follow-up actions.

Interpretation of user eligibility and acceptance

Instrument validation of 88.02% indicates that the assessment items were assessed in accordance with the indicators and variables being measured. The aspects of item suitability to indicators and item relevance obtained 91.67%, while wording clarity obtained 83.33%. This difference indicates that the instrument content has been deemed relevant, but the presentation of sentences still needs to be considered so that each user understands the meaning of the items uniformly. Wording clarity is important because the results of supervision are used as a basis for providing feedback and determining teacher development needs.

The product validation score of 81.88% is considered adequate. The product's conformity to supervision requirements score of 90.63% indicates that the application's core functions align with supervisory management needs. Conversely, the data security score of 71.88% is the aspect with the lowest rating. This indicates that functional feasibility has not been fully matched by information protection strength. Validator input regarding access rights

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separation, navigation consistency, data backup, and account verification should be considered essential requirements before expanding system use.

A user response of 4.06, categorized as good, indicates positive acceptance of the system's use. A Net Benefits score of 4.25 is the highest indicator, indicating that users perceive benefits in documentation, access to supervision results, and follow-up. Meanwhile, Service Quality of 3.88 is the lowest indicator. This difference indicates that the system's core benefits have been perceived, but supporting services such as user manuals, technical assistance, and problem resolution are not yet optimal. Therefore, product implementation needs to be accompanied by training, visual guides, and a technical person responsible for ensuring consistent use of the system's benefits.

Interpretation of teacher capacity improvement

The increase in the average score from 72.77 to 91.70 represents an increase of 18.93 points across the 30 teachers who participated in the assessment. The decrease in the standard deviation from 15.03 to 8.15 indicates that the variation in scores after implementation was smaller than before implementation. All respondents experienced improvement, but the magnitude of the increase varied. This pattern suggests that teachers' responses to the supervision and mentoring process can vary, and therefore, follow-up should not be provided in the same manner to all teachers.

The average N-Gain score of 0.4365 is considered moderate. Twenty-seven teachers, or 90%, fall into the moderate category, while three teachers, or 10%, fall into the low category. No teachers reached the high category. These results should be interpreted in conjunction with the N-Gain effectiveness percentage of 43.65%, which, according to research criteria, is considered less effective. These two results are not contradictory because the N-Gain index describes improvement categories based on score ranges, while the effectiveness percentage uses different interpretation limits. Therefore, the results indicate moderate improvement, but the effectiveness level based on the percentage has not yet reached the sufficiently effective category.

The paired samples t-test yielded $t = -12.469$, $df = 29$, and $p < 0.001$. This value indicates a statistically significant difference between pretest and posttest scores. The Cohen's dz effect size of 2.28 also indicates a significant difference in scores in standard deviation units. However, statistical significance and effect size cannot be used alone to conclude that a product is optimally effective. Interpretation requires consideration of the N-Gain results, duration of implementation, subject characteristics, and study design. Thus, the statistical test results support a change in scores during the implementation period, but do not prove that the entire change is solely due to the application.

Implications for the implementation of supervision and product development

The research indicates that a digital system is more appropriate as a supporting infrastructure for the supervision cycle. The application helps principals store observation evidence, access assessment history, and monitor follow-up. Meanwhile, determining coaching needs still requires direct observation, professional conversations, and an understanding of the classroom context. Combining these two methods allows for more organized documentation without compromising the professional relationship that is a crucial part of academic supervision.

Teacher development priorities can be directed at indicators showing relatively low initial performance, particularly Communication (33%), Critical Thinking (45%), Project-Based Learning (45%), and Joyful Learning (45%). Principals can use the assessment results to design more specific mentoring, for example, helping teachers formulate open-ended questions, design discussions and presentations, develop simple projects, and use assessments that require reasoning. These recommendations represent follow-up actions that align with indicators that still require strengthening, not claims that these activities were tested as separate treatments in this study.

Further product development requires strengthening data security through authentication, role-based access restrictions, regular backups, and setting authority settings for viewing supervision results. Service quality also needs to be improved through simpler user guides, visual examples, and technical support when users encounter issues. This need is increasingly important because limited internet connectivity at the research site can impact application access and smooth use.

Limitations and cautions of interpretation

The research findings need to be interpreted with the limitations of the design and subject coverage in mind. The one-group pretest-posttest design did not include a control group, so the influence of other factors and the possible effects of the pretest on the posttest cannot be fully separated from the effect of product implementation. The research subjects were also limited to 30 teachers and two principals at one foundation, so the results cannot be generalized to educational institutions with different conditions. The relatively short duration of implementation does not allow for measuring the long-term impact on the consistency of teaching practices or student learning outcomes.

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Furthermore, some qualitative data was obtained through written descriptive responses, which may have been influenced by respondents' tendency to provide expected answers. Limited internet connectivity can also impact user experience. Further research should involve more schools, use comparison groups where possible, conduct multiple supervision cycles, and combine teacher proficiency scores with classroom observations, analysis of teaching materials, and student learning outcomes. These steps are necessary to more robustly assess the sustainability of changes in teaching practices.

CONCLUSION

This development research resulted in a web-based digital academic supervision model to support teacher capacity building using the Deep Learning approach at the Az-Zahro Foundation. Development was conducted through a 4D model, encompassing the Define, Design, Development, and Disseminate stages. The product was designed based on the needs of supervision management and teacher pedagogical development, involving administrators, principals, and teachers as system users.

The product's characteristics encompass six aspects: data-driven, flexible, reflective, in-depth learning-oriented, sustainable, and collaborative. These characteristics are implemented through teacher data management, assessment instruments, observation recording, feedback, teacher reflection, follow-up monitoring, and supervision history storage. The supervision instruments integrate the principles of Meaningful Learning, Mindful Learning, and Joyful Learning, as well as the 6C competency dimensions. With this design, the system not only supports digital archiving but also provides a documentation flow for the teacher coaching process.

The product achieved a validation percentage of 81.88%, categorized as adequate, while instrument validation reached 88.02%, categorized as adequate. User responses averaged 4.06, categorized as good. These results indicate that the product can be used as a supporting tool for academic supervision. However, data security aspects, with a score of 71.88% and Service Quality of 3.88, still require attention through strengthening access rights, authentication, data backup, user guides, and technical support.

Measurements of 30 teachers showed an increase in the average ability score from 72.77 in the pretest to 91.70 in the posttest, with an increase of 18.93 points. The results of the paired samples t-test showed a statistically significant difference ($t = -12.469$; $df = 29$; $p < 0.001$), with a Cohen's dz effect size of 2.28. The average N-Gain value of 0.4365 is included in the moderate category, while the effectiveness percentage of 43.65% is included in the less effective category. Therefore, the results of the study indicate an increase in teacher ability after the implementation of the product, but the level of improvement cannot be stated as optimal.

The developed digital academic supervision should be implemented as a supporting tool, not a substitute for direct interaction between principals and teachers. Sustainable results require regular supervision cycles, individual feedback, reflection, and follow-up monitoring. This study was limited to a single institution, a limited number of subjects, a relatively short implementation duration, and a design without a control group. Future research should expand the location and number of subjects, involve a comparison group, conduct multiple supervision cycles, and measure changes in learning practices and student learning outcomes.

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