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Differentiated Science Student Worksheets : What is the Level of Collaboration Skills of Students of the Elementary School Teacher Education Study Program?

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Abstract: This study aims to develop content-differentiated science student worksheets for students of the elementary school teacher education study program, especially on the subject of the human respiratory system, and analyze its effect on student collaboration skills. This research method used research and development with the 4D model (define, design, development, and dissemination). The sample in this study was 142 2nd semester students of elementary school teacher education study program at PGRI University Yogyakarta. The data was taken through student worksheets documentation, score lists, interviews, observations, validation assessment scales, and student collaboration skills questionnaires. The data analysis technique in this study used qualitative descriptive analysis techniques. Based on the research results, the student worksheets products that have been developed meet the validity criteria with an overall average of 97% in the very valid category. The validity and reliability results of the student collaboration skills questionnaire for the student worksheets developed have met the valid and reliable criteria. The results of the student collaboration skills trial given to 142 students on the developed student worksheets were the order of the number of students who always carried out collaboration skills starting from the responsible aspect (79%), the respect aspect (77%), the productive work aspect (71 %), aspects show flexibility (71%), and aspects contribute actively (38%). Meanwhile, the average number of students is 22% of students at a good level in collaborating and 78% of students are very good at collaborating.

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Introduction

The character, abilities, and skills of each individual are different. This diversity of intelligence (multiple intelligences) is the basis for expanding the potential of each individual. Multiple intelligences is a theory of intelligence put forward by Howard Gardner, a developmental psychologist and professor at Harvard University from Project Zero (research group) in 1983. Gardner (1983) redefines intelligence from a narrow meaning to a broader meaning by stating that a person's intelligence is not measured from the results of standard psychological tests, but can be seen from a person's habit of solving his problems (problem-solving) and a person's habit of creating new products that have cultural value (creativity). Various types of multiple intelligences include verbal-linguistic intelligence, logical-mathematical intelligence, visual-spatial intelligence, bodily-kinesthetic intelligence, musical intelligence, intrapersonal intelligence, interpersonal intelligence, naturalistic intelligence, and existential intelligence. This diversity of multiple intelligences results in the

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level of understanding of a material concept for each individual to vary according to the intelligence they have (Kamid et al., 2018).

Understanding concepts is very important in any learning process. Understanding science concepts is an individual's effort to understand an abstraction of objects, events, activities, facts, and relationships between elements in his mind, which later can be implemented in everyday life (Umardianti et al., 2023). Understanding the concept itself plays an important role, especially in learning because understanding is a fundamental ability that students must have when learning more advanced lesson concepts. The level of knowledge that varies among individuals will be meaningful if they understand the concept according to their ability level. In the learning process, various learning tools are used to improve students' ability to understand concepts (Zuleni & Marfilinda, 2022).

Student worksheets are a learning tool that is useful as a medium for giving direction and guidance for students to complete assignments using available scientific steps to instill conceptual knowledge in students. The positive impact of using worksheets for students can improve creative thinking abilities (Sari & Wulanda, 2019), critical thinking (Setyowati & Kurniawati, 2017), improve problem-solving ability (Widodo et al., 2023), improve concept understanding (Munfaida et al., 2022), as well as mastery of 21st-century life skills which can be integrated into worksheets (Widowati et al., 2023), so it is hoped that through the learning process that involves this higher-level thinking process can produce quality students (Novia Rizki & Kurniawati, 2022). Using worksheets effectively improves learning achievement in the scope of science (Amita Sari & Kurniawati, 2024). There are at least six (6) elements and formats that must be present in an student worksheets, including (1) title; (2) tools, materials, and study instructions; (3) competencies to be achieved; (4) Supporting information in the form of problems or events; (5) tasks or work steps; and (6) research in the form of reports of observations or experiments (Prastowo, 2014). The elements and format of the worksheet aim to facilitate student performance in collaborating to complete the assignments on the worksheet.

Collaboration skills are an indicator of 21st-century 4C skills, and students must possess them to prepare their personal qualities to compete and be effective in the future. Presented by Santrock (2007) that collaboration skills are the ability to build relationships with other people, especially in participating in learning activities with mutual respect, to create a conducive and good learning atmosphere. Collaboration skills should be a learning subject that needs attention. Collaboration skills play a role in practicing effective division of labor, improving character and student responsibility, and merging information from various sources of knowledge, perspective, experience, and cohesiveness (Ulhusna et al., 2020). From the description above, collaboration skills need to be considered in the learning process to improve the quality of graduates who can be competitive and efficient.

Based on the analysis of the worksheet documentation of students of the elementary school teacher education program at UPY, it was found that the worksheet only fulfilled five of the six elements, namely the title, study instructions, competencies to be achieved, assignments, and research. In addition, the work steps on student worksheets do not require students to find concepts because they do not guide students to solve a particular problem or event. The student worksheets have not yet implemented differentiated learning, which makes students stiff and forces them to understand the material. Based on interviews conducted with lecturers supporting science courses, it was found that the level of understanding of student material was relatively low. It is proven by the percentage of science test results, which is 58% of students who score below 80. One of the factors that influences students' understanding of material concepts is their cognitive abilities, so each

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student's individual abilities are different from one another. It aligns with the research results by Kusmiyati & Sugoni (2022) namely learning that integrates an individual differences approach, which influences learning outcomes.

Apart from that, the results of observations of students of the elementary school teacher education study program at UPY showed that at least one member from each group was less active in participating and even tended not to contribute or take responsibility for completing assignments. Students' skills in collaborating are still low, there is a lack of creativity, students' activities in collaboration are only when discussing material, and they have not shown solid cooperation in completing assignments. In order to improve the obstacles faced, improvements in the learning process are needed (Atmojo & Kurniawati, 2018b; Fathoni et al., 2021). One thing that can influence students' collaboration skills is worksheets. This is supported by the statement (Nurjanah et al., 2020) namely worksheets influence students' collaboration skills and understanding of concepts.

Worksheets should meet students' needs to produce something effective, increase creativity and reflective thinking abilities (Syamsuddin et al., 2023) and utilize the intelligence potential that exists in every student. It is closely related to humanistic learning theory, namely educational practices that view humans as an intergalactic unit, which must be upheld. This basic view can color all systematic education components wherever and regardless of type. This theory is more interested in learning in its most ideal form than learning as it is, like what we can observe in the everyday world (Nast & Yarni, 2019). Applying humanistic theory to learning activities should lead students to think inductively, prioritize practice, and emphasize the importance of student participation in learning (Sumantri & Ahmad, 2019). This humanistic theory was adapted into the current education curriculum in Indonesia, namely the independent curriculum, which lies in differentiated learning guides in content, process, and product.

Differentiated learning can help students achieve optimal learning outcomes and provide ample space for students to demonstrate what they have learned so that differentiated learning indirectly encourages student creativity (Herwina, 2021). A differentiated approach can be applied in science learning because it can accommodate students' learning needs by considering students' interests, profiles, learning styles, and learning readiness (Wahyuni, 2022). The implementation of differentiated learning will be a curriculum that is flexible and not rigid or that only believes in one way to achieve educational goals in schools (Wahyuningsari et al., 2022). Research by Sarie (2022) and Cahya et al. (2023) state that differentiation learning can develop creative thinking and collaboration abilities between students.

Based on the explanation above, one solution to awaken student collaboration skills is to use learning tools like worksheets and integrate differentiation learning into them. It is supported by differentiation learning innovation from the research of Özdeniz et al. (2023), who designed different science modules and found that there was an effect of their application on students' scientific reasoning and scientific process skills in a mixed learning environment. Other research that supports this research is the work of (Atmojo & Kurniawati, 2018a), which develops a thematic textbook with a science, environment, technology, and society (SETS) vision to instill the concept of Sustainable and Renewable Energy. Meanwhile, this research uses innovative learning media in the form of student worksheets with content differentiation, especially on the subject of the human respiratory system (Kurniawati et al., 2022), and analyzes its effect on collaboration skills.

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Research Method

This research is research and development. The development research method used in this research refers to a model research design Thiagarajan (1974) 4D, namely define, design, development, and dissemination. The population of this study was all students of the elementary school teacher education study program at PGRI University Yogyakarta. The sample for this research was 2nd-semester students of the elementary school teacher education study program at UPY in 4 classes, namely class A4-22. A5-22, A6-22, and A7-22, totaling 142 samples.

Data collection techniques used assessment scales and student collaboration skills questionnaires. The assessment scale given to 6 expert validators was used to measure the feasibility of differentiated student worksheets science products. Researchers made a grid of material and media expert validator assessment scales consisting of didactic, construction, and technical aspects. Student worksheet products declared suitable for use are then tested for their effect on student collaboration skills. The researcher made a questionnaire grid for student collaboration skills consisting of actively contributing, working productively, taking responsibility, showing flexibility, and respecting. The assessment by expert validators and measuring the level of student collaboration skills are analyzed using the questionnaire assessment criteria shown in Table 4 (Riduwan, 2012):

Table 1. Criteria for Student Collaboration Skill Results

Percentage	Category
81% - 100%	Very good
61% - 80%	Good
41% - 60%	Pretty good
21% - 40%	Not good
0% - 20%	Very Less Good

Results and Discussion

The results of this study are learning products in the form of student worksheets in the natural sciences subject on the human respiratory system which are arranged based on suitability with individual student abilities, precisely on the aspect of student learning readiness which is summarized in the differentiation learning strategy. The development of this student worksheets was designed using the 4D development model by Thiagarajan (1974) which consisted of 4 steps, namely define, design, development, and dissemination. More detailed explanations are outlined in each of the following steps.

Define

This step aims to analyze problems that occur in the learning process and carry out an introduction which includes documentation analysis, needs, theoretical analysis, material analysis, and student analysis. The data collection process resulting from the preliminary study was carried out in February 2023 which produced several data related to student worksheets, learning processes, and collaboration skills of students of the elementary school teacher education study program at UPY. The description of each analysis is explained in detail in table 5.

Table 5. Description of the Define Steps

Step	Data collection		Results Obtained
Problem analysis	Collection of references/sources	✓	• Student skills are still low in collaborating, there is a lack of creativity, student activities in collaboration are only when discussing material, and they have not shown solid cooperation in
	Interview	✓	
	Documentation	-	

			completing assignments • Lecturers have never assessed students' collaboration skills • The results of the interview obtained were that student collaboration skills at elementary school teacher education study program at UPY were still lacking. One of the factors causing this is the absence of learning that adapts to students' abilities.
Documentation Analysis	Collection of references/sources	-	• From the didactic aspect, the available student worksheets do not meet individual student differences • From the construction aspect, instructions and questions in student worksheets have not been able to direct students to experiment and foster student collaboration skills • From a technical aspect, the appearance of the available student worksheets is not attractive, and the characteristics of the students
	Interview	-	
	Documentation	✓	
Needs Analysis	Collection of references/sources	-	• The interview results obtained were that during the learning process, the lecturer had used several learning resources, such as books, learning videos, and modules, but the learning resources could not be used to foster student collaboration skills
	Interview	✓	
	Documentation	-	
Theory Analysis	Collection of references/sources	✓	• The results of the reference collection that have been obtained have been systematically arranged in the research background and discussion sections.
	Interview	-	
	Documentation	-	
Material Analysis	Collection of references/sources	✓	• The results of the collection of human respiratory system content obtained have been systematically compiled in student worksheets
	Interview	-	
	Documentation	-	
Student Analysis	Collection of references/sources	-	• Students are less active in working on and collecting assignments given by lecturers • Students are less active in discussing in class • Students are categorized into three groups, namely students not ready to learn, students ready to learn, and students very ready to learn • Students like the appearance of teaching materials accompanied by attractive pictures and colors
	Interview	✓	
	Documentation	-	

Based on Table 5, it can be explained theoretically and empirically that there is still a lack of student collaboration skills. One thing that can influence students' collaboration skills is worksheets. It is supported by the statement of Nurjanah et al. (2020), namely that worksheets influence students' collaboration skills and understanding of concepts. So, it is necessary to analyze the student worksheet documentation used during the learning process.

Other analysis results from Table 5 also explain that in terms of didactic, construction, and technical aspects, (1) the available worksheets do not meet the individual differences of students; (2) instructions and questions on student worksheets have not been able to direct students to experiment and develop student collaboration skills; and (3) the appearance of the

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available student worksheets is not attractive and by the student's characteristics. At the same time, Zahary (2017) revealed that student worksheets must meet didactic, construction, and technical requirements. Based on the previous explanation, researchers are interested in producing student worksheets that are differentiated according to the level of student learning readiness to instill student collaboration skills.

Design

Designing differentiated student worksheets requires collecting materials such as images, compiling questions, and selecting colors that match the appearance of other image icons. The products developed are designed to meet appropriateness, accuracy, clarity, and attractive presentation and appearance design. So the things to consider in designing worksheets are (1) didactic elements, including the presentation of work steps, content (material), images, and video links that are adjusted to the level of student learning readiness to facilitate individual differences and student characteristics; (2) construction elements include completeness and suitability of components, instructions, tools, and materials, work steps, indicators and course objectives, presentation of command sentences or questions as well as display of worksheets adapted to the student's level of learning readiness; and (3) technical elements including the clarity and accuracy of material presentation, activity procedures, spelling, appearance and ease of use of worksheets.

The worksheets developed focus on the natural sciences subject of the human respiratory system for students of the elementary school teacher education study program at UPY in semester 2. The worksheets consist of covers, identities, objectives and indicators, tools and materials, work steps, and a place to write down the work results accompanied by pictures with attractive colors and according to the subject matter. Worksheets are classified into three categories according to the level of student learning readiness, namely category A, category B, and category C. Category A worksheets are intended for groups of students who are on average not ready to learn, so a worksheet is designed that contains instructions for students. To read, listen to, or watch various literature. Category B worksheets for groups of students ready to learn to contain directions for doing experiments on human respiratory mechanisms. Meanwhile, the students who were very ready to learn were presented with a category C worksheet with the assignment to make an experiment on the dangers of smoking for the health of human respiratory organs. Each category on the worksheet contains questions according to the assignment directions for each category and gives students the freedom to present the results of their work in whatever form they wish.

Worksheets are specifically designed for students to work on in groups so that they are expected to influence student collaboration skills. So, at this design stage, the researcher also developed a student collaboration skills questionnaire instrument to measure students' level of collaboration skills after using differentiated student worksheet products. The collaboration skills questionnaire consists of 15 statements by dividing 4 statements on aspects of actively contributing, 3 statements on aspects of working productively, 2 statements on being responsible, 3 statements on aspects of showing flexibility, and three statements on respect. This questionnaire uses a rating scale, namely never 1 point, often with 2 points, and always with 3 points, to facilitate researchers in categorizing the level of collaboration skills possessed by students.

Development

The next procedure for developing student worksheets is to carry out product validation by expert validators to test the feasibility of materials and media on worksheets from didactic, construction, and technical aspects before being tested on campus. Based on the validation process, the student worksheet product that has been developed has a final

percentage of didactic validation of 94%, construction validation of 98%, and technical validation of 99%, so the total average percentage of worksheet validation is 97%. The total average result obtained was 97%, which shows that the worksheet product has met the criteria for being very valid for testing with several revision suggestions from the validators. The worksheet validation results explain that the worksheet contents are based on existing needs, contain elements of differentiation according to individual student differences from the perspective of student learning readiness, have an attractive appearance, and are based on student characteristics.

In the next stage, after validating the worksheet product, the researcher tested the validity and reliability of the student collaboration skills questionnaire. The validity test was carried out to identify the validity of the question items in the questionnaire used as a research instrument. Reliability tests are given to identify the instrument's actuality as a data collection tool.

Based on the preliminary study results, researchers created a questionnaire to collect data on the level of student collaboration skills. Testing the validity and reliability of the collaboration skills questionnaire is carried out so that the results obtained can be trusted. Each item of the collaboration skills questionnaire containing 15 statements was declared valid after the calculation process using SPSS with a value of r table = 0.1648, declared valid because the Corrected Item-Total Correlation value (r count validity) in table 8 for each statement item is greater than r table. Each item of the collaboration skills questionnaire containing 15 statements was declared reliable after the calculation process used SPSS with a value of r table = 0.1648, declared reliable because the value of Cronbach's Alpha if Item Deleted (r count reliability) in table 9 for each item statement is greater than r table. Overall, 15 statements were declared reliable with a calculated r-value (0.877) greater than the r table (0.1648). The decision is to use the significance level or α = 5%; the collaboration skills questionnaire is reliable (consistent).

Dissemination

The analysis results of the development process became the basis for testing the worksheets on semester 2 PGSD UPY students. The researcher integrated this trial process into the dissemination step. The worksheets distributed for use in the learning process are adjusted to the different levels of learning readiness of the 2nd-semester students of the elementary school teacher education study program at UPY, totaling three levels and 142 students. After using the worksheet, 142 students filled out the collaboration skills questionnaire.

From the questionnaire results, it was found that in the aspect of actively contributing, 8% of students never, 51% of students often, and 38% of students always actively contributing in collaboration. Then, 1% of students never, 28% of students often, and 71% always work productively. The next aspect is that 0% of students never, 21% of students often, and 79% of students are always responsible. Furthermore, 0% of students never, 28% of students often, and 71% of students always show flexibility. Finally, 1% of students never, 23% of students often, and 77% of students always show an attitude of respect.

The highest percentage of "always" choices is 79% in being responsible, and the lowest is 38% in actively contributing. The order of "always" from the highest starts from the aspect of being responsible (79%), the aspect of respect (77%), the aspect of working productively (71%), the aspect of showing flexibility (71%), and the aspect of actively contributing (38 %). This percentage explains the number of students in each choice in aspects of collaboration skills. Meanwhile, regarding the overall average category of collaboration skills, 22% of students are at a good level of collaboration. As many as 78% of

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students are very good at collaborating. So, differentiated worksheets affect students' collaboration skills. Worksheets have a substantial effect on improving student performance. The use of worksheets as an instructional tool can enhance student-centered learning, encourage collaboration skills and problem-solving abilities, and can be used to inform instructors about what students are struggling with, thus providing an opportunity to get valuable and timely feedback (Weir et al., 2019). This is similar to the results of the study by Octaviana et al. (2022) which states that worksheets are effective for improving students' collaboration skills.

Instructions on worksheets can develop students' collaboration skills. This is supported by the results of research which explain that worksheets can develop students' ability to engage with each other, evaluate their ideas, monitor working together, and manage failure when solving problems (Rahmawati et al., 2020) as well as provide detailed guidance in terms of tasks and investigation procedures (C. Wang & Le, 2022). The presentation of instructions on worksheets should be able to facilitate the needs of students, as well as the results of research explaining that it is important to customize the learning process based on one's individual abilities (Majoko, 2019).

One of the teaching materials that can be developed to be used in the learning process and adapted to student's individual abilities is worksheets. The design of instructions on varied worksheets or differentiated worksheets is adjusted based on the different individual abilities of students. The urgency of this development is from the results of research which states that there is a need for improvement in three learning principles, namely "collaboration"; "differentiation"; and "collective knowledge" (X. Wang et al., 2021). Combining different access mode to materials, including differentiated worksheet instruction can help the learning process (Glas et al., 2021).

Based on the research results as well as the review and analysis of several previous relevant studies, it can be explained that the product of worksheets with varied instructions or differentiated worksheets in this study is an innovation in the renewal of teaching materials in the learning process. The application of this differentiated worksheet can affect student collaboration skills, as seen in the pie chart in Figure 2, namely 22% of students are at a good level in collaboration and as many as 78% of students are very good at collaboration. This data is supported by previous research statements that student collaboration skills were successfully trained by using worksheets (Naila et al., 2020). Other research also explains that differentiated learning correlates with student collaboration skills in the learning process (Haelermans, 2022). So, differentiated worksheets can affect student collaboration skills.

However, besides that several other learning aspects can affect collaboration skills, including the application of Lesson Study (Salasiah et al., 2022), guided inquiry learning model (Sarifah & Nurita, 2023), the Team Games Tournament/TGT learning model (Rosyida et al., 2023), Project Based Learning (PjBL) model assisted by food chain box media (Lutfiana & Handayan, 2023), and the Learning Cycle 7E learning model (Novita Sari et al., 2022). The impact of worksheets is not only on collaboration skills. There are other aspects that worksheets can influence, such as problem-solving abilities (Umar et al., 2022), the ability to understand the concept of science (Maulani et al., 2022), scientific literacy skills (Cholifah & Novita, 2022), and critical thinking skills (Wahono et al., 2022).

Conclusion

Based on the research results, the student worksheet products that have been developed meet the validity criteria with an overall average of 97% in the very valid category. The validity and reliability results of the student collaboration skills questionnaire for the student

worksheets developed have met the valid and reliable criteria. The results of the student collaboration skills trial given to 142 UPY PGSD students on the developed student worksheets were the order of the number of students who always carried out collaboration skills starting from the responsible aspect (79%), the respect aspect (77%), the productive work aspect (71 %), aspects show flexibility (71%), and aspects contribute actively (38%). Meanwhile, the average number of students as a whole is 22% of students at a good level in collaborating, and 78% of students are very good at collaborating.

Recommendation

The results explained the effectiveness of differentiated student worksheets in improving students' collaboration skills. Lecturers and educators can use this innovation in learning to measure other instructional objectives. Product innovation can also be adjusted to the differentiation approach we want. Along with the times, this differentiated student worksheet is one of the tools indicated to improve education standards in Indonesia.

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