



Designing student worksheet in human respiratory system based on inquiry to promote 21st-century skills

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ABSTRACT

A student worksheet is one of the learning resources containing work intended to make students to be more active in learning. A student worksheet is designed based - inquiry so that learning is more meaningful and student-centered. Investigation optimally involves all students' ability to search and investigate systematically, critically, logically, analytically, so that they can formulate their findings confidently. This study aims to produce student worksheet based - Inquiry with profiles and qualities that are feasible to use in classroom learning, developed by adapting the ADDIE model. The validity of the worksheet in human respiratory system developed is measured from the result of validation by the expert validator, the quality, and practicality of the worksheet seen from the responses given by students and teachers. The data of the development results were analyzed descriptively qualitatively. The results showed that the worksheet based-Inquiry had fulfilled the three requirements for proper worksheet preparation that is didactic, constructive, and technical requirements. Student worksheet based-Inquiry declared very valid with an average value of 3,70 and was feasible to use. A student worksheet was also lied in a first category based on the responses of students and teachers with scores of 82,92% and 83,50%, respectively, so it was concluded feasible to be used in learning.

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INTRODUCTION

The biology is now defined as the science of studies life (Sokal & Crovello, 1970; Noor, 2002; Ristanto, 2017). Student before arriving at the middle school, having a concept design regarding living (Klymkowsky, Garvin-Doxas, & Zeilik, 2003; Ozdem, Cavas, Cavas, Cakiroglu, & Ertepinar, 2010). Students have lots of obstacles to assimilate the characteristic of the living being (Nouredine and Zouhaire, 2017; Goodman, 2010). The human respiratory system is one of the biological material

in the middle school curriculum. The scope of this material includes the respiratory organs, mechanisms, abnormalities and diseases. Respiratory organs include the nose, pharynx, larynx, trachea, bronchi, bronchioles and lungs. In which the exchange occurs in the lungs (Al Khalidi et al., 2011).

Respiratory system in humans has some theoretical study, so that misconception in this subject also occur frequently. If it is left unchecked, it will have an impact on the new concept learned and the learning outcome (Sholikah, Rahmawati & Prajoko, 2018). For this reason, the teacher must be adapted to the teaching-learning situation of difficulties encountered by students (Fauzi & Fariantika, 2018). The teachers must correct students' prior knowledge and support students in integrating new knowledge with their existing ideas. Ristanto (2011) argued that confrontation between preknowledge and new experience is the critical element in teaching toward understanding. Learning that student understanding is one of the characteristics of quality learning.

Quality learning for the twenty-first century is as crucial as identifying the new competencies that today's student need to develop (Djamahar, Ristanto, Sartono, Ichsan, & Muhlisin, 2018). Explores the learning environments of students may contribute to the development and mastery of 21st-century competencies and skills (Prajoko, Amin, Rohman & Gipayana, 2017; Dewi & Ichsan, 2018). Quality learning will produce the quality of human resources. Excellent human resources are needed in the competitive era in the 21st century. The role of education is necessary to create a generation that is reliable and character based. Therefore, the learning paradigm must be shifted from teacher-centered learning to student-centered learning (Djamahar et al., 2018; Ristanto, 2011; Pratama, 2018). Students must be active and be part of learning activities (Utomo, 2016; Sartono, Rusdi & Handayani, 2017).

The activity of students in learning can be controlled through the presence of learning devices that can change the way students learn to be more meaningful. The method in question is the use of a student worksheet. The existence of student worksheets in learning is very influential for teachers and students. According to Ozmen & Yildirim (2005) added that a student worksheet is a sheet that contains work or materials that make students to be more active in taking the meaning of the learning process. Pratita et al. (2018) added that student worksheet is included in learning media. Therefore, the student worksheet to be used should optimize student learning outcomes (Choo, Rotgans, Yew, & Schmidt, 2011; Hanim et al., 2017), added that student worksheet can be a solution and choice for teachers in improving learning outcomes and learning motivation of students.

One of the successes in learning is determined by the presence of learning resources as a tool to increase learning motivation, clarify and facilitate the student for learning activities, including success in learning biology. The material in biology lessons has characteristics that are loaded with problems. For this reason, the application of specific strategy innovations is needed to overcome the complex issues occur. One of them is by developing the student worksheet based-inquiry. An inquiry is a process for obtaining information by conducting observations and experiments to find answers or solve problems for questions or formulation of issues by using critical and logical thinking skills. Chinn & Malhotra (2002) and Ristanto (2011) argued that traditionally the simple inquiry emphasized in the science classroom is taught via the scientific method, consist of 5 steps: observe, question, experiment, interpret the result, and accept or reject a hypothesis.

The teacher in inquiry based learning provides the input for the student with a problem to investigate along with the procedures and materials. This type of inquiry learning is used to teach a specific concept, fact or skill and leads the way to open inquiry where the student formulates his problem to investigate (Abdi, 2014; Istiana & Awaludin, 2018). Inquiry-based learning became synonymous with terms such as discovery learning, hands-on learning, activity-based instruction, and project-based instruction (Ristanto, 2011; Pratama, 2018).

Learning through the inquiry process allows students to use all their potential, especially their mental processes to find out their concepts or principles of science and can train other mental processes that characterize a scientist. The inquiry-based learning approach suggested by educational scientists are; learners master learning units by obtaining data through asking questions and doing

research in the knowledge construction process, using their creativity (Hogan & Berkoits, 2000; Ristanto, Zubaidah, Amin, & Rohman, 2018).

Student worksheet based-inquiry was developed based on the fact that during the learning process most students were still less critical and even on the teacher-centered, so that gave impact on the quality of learning, in this case, the learning outcomes of students. The importance of student worksheet based inquiries was developed and applied because it had a good effect on students. As reported by Damayanti et al. (2012), that inquiry-based worksheets can develop students' critical thinking skills, improve concept understanding (Kurniawan et al., 2014), and improve science process skills and student motivation.

The results of observations at SMP Kupang Timur obtained information that the students worksheet used in learning so far has not activated students, and students worksheet was only a collection of questions without a stimulus that stimulates students' thinking skills. One indicator of students' low thinking ability can be seen in the learning outcomes achieved which was still largely not yet achieving mastery learning (60%). Based on the results of the observations and the results of the research stated above, it indicates that it is necessary to develop a student worksheet based - Inquiry specifically on human respiratory system material. This material becomes the object of study because in this material, many students have weaknesses in understanding biological concepts such as the mechanism of human breathing. On the other hand, students tend to understand the theory while the processes have not yet understood. The results of this development are expected to be applied by biology teachers in the implementation of classroom learning and can facilitate students in understanding biological concepts.

METHOD

Design of the Study

This research used developmental research adapting by the ADDIE model. This development research produces student worksheets on human respiratory system material. The model used was adapted to the development of the ADDIE model (Arkün, & Akkoyunlu, 2008), which includes the stages of Analysis, Design, Development, Implementations, Evaluation. The design of the ADDIE models is presented in Figure 1.

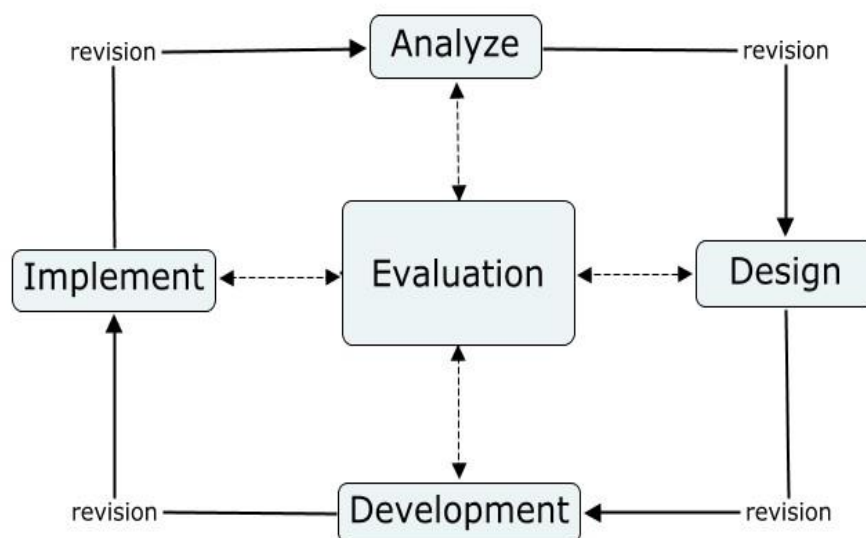


Figure 1. ADDIE Model Development Chart (Adapted form Ngussa, 2014)

Analysis-phase was carried out by an analysis on aspects of curriculum, media, and material. The Design-phase produces a framework for student worksheets. The development phase, the resulting prototype was began to be validated and revised. Application phase, the implementation

phase was carried out by testing junior high school students at Kupang Timur. Product trials were carried out in small groups covering three schools of 9 students each. Selection of product trial subjects was based on purposive sampling technique. Evaluation phase was done to measure the feasibility use of student worksheets developed. If the evaluation results have not yet reached the goal, revisions was made. After going through the product testing phase, the product was measured again based on the questionnaire of students response.

Instrument

The primary analysis instrument used interview guidelines. Interviews were conducted with teachers and students. The expert validation instrument used an assessment sheet consisting of several student worksheets based inquiry validation indicators. Product testing instruments in the form of questionnaires response of teachers and students to worksheets that have been developed. The tools used were: Initial analysis instruments for teachers and students using unstructured interview guidelines. Used to obtain data as a basis for designing inquiry-based student worksheets, expert validation instruments (media experts and material experts) using assessment sheets consisting of some indicators of student worksheet based-inquiry validation, limited product trial instruments in the form of devices containing questions (questionnaire) related to student and teacher responses to student worksheets that have been developed.

Data Analysis

Processing data in this study was carried out by descriptive statistical analysis. The technique used to analyze the data of expert validator's was an average analysis technique, stated that the assessment can be done by calculating the number of values of each item divided by the number of respondents. The criteria of the expert validator's assessment (media experts and material experts) was used to determine validly or not the product developed. The validity criteria for worksheet sheets set were: 3,26 – 4,00 (**valid**, not revised), 2,51 – 3,25 (**quite valid**, not revised), 1,76 – 2,50 (**less valid**, partial revision), 1,00 – 1,75 (**invalid**, total revision). The data analysis of the questionnaire of teacher and student's responses was measured using the Guttman scale. Measuring scale with this type, will get a firm answer, namely "Yes" or "No" The results of the percentage scores were then converted to feasible (0% - 20%), less feasible (21%-40%), enough (41% - 60%), feasible (61% - 80%), and very decent (81% - 100%) (Windiastruti et al, 2018).

RESULT AND DISCUSSION

The results of the initial analysis of students' needs for the presence of student worksheet based inquiries are based on the shortcomings found in the worksheets they have used so far, learning objectives are not formulated operationally, and students have a less active role in learning. Besides, the assignments given have not raised the life phenomena that have occurred, in the material of the human respiratory system only contains theory without any practicum so that students only know the theory without understanding the process.

The student worksheet based inquiry points that have been developed have three criteria for good worksheet recruitment, such as didactic, constructive, and technical requirements. The three components can be seen in the validation sheet that was assessed by the validator. The student worksheet based inquiry developed has excellent quality based on the results of the analysis that has been carried out. As for the results of the study carried out are as follows:

a. The Result of expert validator's assessment

The feasibility of the product developed can be seen from the results of the expert validator's assessment. The validator of the student worksheet based inquiry consists of four validators on the student worksheet based inquiry which are indicators of evaluation, including covers, worksheet contents, presentation of worksheet material, language usage, and display of worksheets. The results of the validation analysis of student worksheet based inquiry obtained an average value of 3.70 with

very valid and feasible criteria to use. The complete evaluation presented in [Table 1](#).

Table 1.

Validator assessment of student worksheet based inquiry.

No.	Aspect	Validator				Average
		I	II	III	IV	
1	Cover	3,67	3,33	3,67	3,67	3,59
2	Contents	3,60	3,80	4,00	3,60	3,75
3	Material Presentation	3,67	3,67	3,67	3,33	3,59
4	Language Usage	3,67	3,67	4,00	3,67	3,75
5	Display of student worksheets	4,00	3,67	3,67	4,00	3,84
Average		3,72	3,63	3,80	3,65	3,70

During the validation process, there were several suggestions as revised given by the four validators for the validity and feasibility of student worksheets including. 1) Cover: the image was needed to be enlarged so that the information in the picture can be seen, the school identity and class for the allocation of student worksheets were needed to be added including the description of the current semester. 2) Contents: student worksheets made were not synchronized with other learning tools such as syllabus and lesson plans, the material included was just short material and for complete article self-made in the form of teaching materials. Inquiry-based learning phases have not appeared on student worksheets, learning indicators on student worksheets have not been arranged in stages according to the cognitive level of students. 3) Display: in the phase of formulating the problem on the worksheet, students have not been given space to write the formulation of the issue found, need to add supporting information or stimulus in the student worksheet before being asked questions, display images, writing, and colors need to be clarified and arranged proportionally. 4) Language: the sentence on the learning indicator needed to use operational verbs, editorial learning objectives should not used question words. The suggestions from the validator and the full revision results showed in the [Table 2](#).

Table 2.

Several revisions to the student worksheet based-inquiry.

No.	Part	Before Revised	After Revised
1	Cover	the image was needed to be enlarged so that the information in the picture can be clearly seen, the school identity and class for the allocation of student worksheets were needed to be added including the description of the current semester.	the image display has been arranged proportionally, the identity of the student worksheet was allocated to the school, class and current semester are completed.
2	Content	Student worksheets made weren't synchronized with other learning tools such as syllabus and lesson plan. The material included was just short material and for complete material self-made in the form of teaching materials.	Student worksheets made were synchronized with other learning tools such as syllabus and lesson plans the material entered was only a brief description of the material as a form of stimulus to the problem and also equipped with stimulus images to lure students to formulate problems.
		Inquiry-based learning phases have not appeared on student worksheet.	Inquiry-based learning phases have appeared on student worksheets accompanied by empty spaces for students to fill in each of the suggested ones learning indicators on

No.	Part	Before Revised	After Revised
			student worksheets have been arranged in stages according to the cognitive level of students.
3	Display	Learning indicators on student worksheets have not been arranged in stages according to the cognitive level of students. In the phase of formulating the problem on the worksheet, students have not been given space so that students can write the formulation of the problem found.	All stages in inquiry-based learning have been prepared space so students can write and explore each of their answers.
		Needed to add supporting information or stimulus in the student worksheet before being asked questions.	Before entering into the subject matter, supporting information or stimulus in the student worksheet has been added.
		Display images, writing, and colors need to be clarified and arranged proportionally.	Display of images, writing, and colors have been improved and arranged proportionally.
4	Language	The sentence on the learning indicator needed to use operational verbs, and editorial learning objectives should not use question words.	The verdict on the learning indicator has used the operational verb, for example, the word "understanding" is replaced by "describing" and others, the learning goal is not using the word for example "how." the question word has been removed, and the sentence editor is corrected.

b. Students and teacher response to worksheet based-inquiry

The results of the questionnaire analysis of the responses of students and teachers in each statement in the small-scale trials in full are presented in [Table 3](#) and [Table 4](#).

Table 3.

Students' responses to student worksheet based inquiry.

No	Statement	Answer (%)		Category
		Yes	No	
1	Student worksheets based-inquiry encourage students to learn better.	93	7	Very decent
2	The presentation of the Student worksheet makes students interested in working on the questions.	86	14	Very decent
3	Student worksheet based-inquiry give more learning experience for students.	86	14	Very decent
4	Students are actively involved in learning by using student worksheets based-inquiry.	93	7	Very decent
5	Student worksheets based-inquiry needs to be continuously applied because they stimulate thinking skills.	3	7	Very decent
6	Student worksheets based-inquiry provide opportunities for discussion, exchange of ideas, and thoughts with group friends	100	0	Very decent
7	Student worksheets based-inquiry needs to be applied in	93	7	Very decent

No	Statement	Answer (%)		Category
		Yes	No	
8	biology learning. The problems presented in the student worksheet based-inquiry are by everyday life.	86	14	Very decent
9	Student worksheet based inquiry increase student confidence in learning.	86	14	Very decent
10	Student worksheets based-inquiry make it easier for students to remember and understand biological material.	93	14	Very decent
12	Learning biology using student worksheet based-inquiry can make time efficient.	86	14	Very decent
Average		82,92	9,33	Very decent

The data in Table 2, after analysis, it was obtained that the percentage of students' responses to student worksheet based inquiry was 82,92% with very decent categories. Furthermore, the teacher's response was 94%. This shows that the response of students and teachers to the use of student worksheet based inquiry are presented in Table 4.

Table 4.
Teacher's response to the Student Worksheet Based-Inquiry

No	Statement	Answer (%)		Category
		Yes	No	
1	Student worksheets based-inquiry encourage students to learn better.	93	7	Very decent
2	The presentation of the student worksheet makes students interested in working on the questions.	90	10	Very decent
3	Student worksheet based-inquiry give more learning experience for students.	86	14	Very decent
4	Students are actively involved in learning by using Student worksheets based-inquiry.	95	5	Very decent
5	Student worksheets based-inquiry needs to be. continuously applied because they stimulate thinking skills	95	5	Very decent
6	Student worksheets based-inquiry provide opportunities. For discussion, exchange of ideas, and thoughts with group friends.	100	0	Very decent
7	Student worksheets based-inquiry needs to be applied in biology learning.	93	7	Very decent
8	The problems presented in the student worksheet based-Inquiry are by everyday life.	85	15	Very decent
9	Student worksheet based inquiry increase student confidence in learning.	90	10	Very decent
10	Student worksheets based - Inquiry make it easier for students to remember and understand biological material.	90	10	Very decent
12	Learning biology using student worksheet based-inquiry can make time efficient.	85	15	Very decent
Average		83,50	8,17	Very decent

Table 3 shows that the teacher response to the student worksheet based-inquiry was developed very decent. After the data of teacher response were analyzed, obtained the average percentage was 83.50%. The results of the response indicate that student worksheets based-inquiry could be applied in biology learning.

The student worksheet developed was adapted from ADDIE model (Arkun & Akkoyunlu, 2008), which includes the stages of Analysis, Design, Development, Implementation, Evaluation. The analysis phase was carried out to find out some aspects needed in developing student worksheets in this case related to curriculum, media, and material. The analysis focused on topics that has not been explored more deeply by students. The design phase was related to the design of the student worksheet framework developed based on the needs analysis. In the design phase, the focus were on learning objectives, content, material analysis, training, activity planning, media selection and assessment instruments used in student worksheets. Product design at this stage cannot be separated from the results of needs analysis. The initial product development phase was followed by a series of revisions based on the input of the validator (media expert and material expert). The application stage tested the product in a limited manner on the product trial subject based on the Purposive sampling technique. The Evaluation Phase was used to measure the achievement of the feasibility of using development products. If the evaluation results have not yet achieved the objectives to be completed, then revisions were made. Changes were made following the results of the evaluation or needs that have not been achieved. After going through the product testing phase, the product was then measured again based on the questionnaire responses of students and teachers. Some research results related to the development of learning devices that use the ADDIE model were reported by Aldoobie (2015), and Fitriani et al. (2016).

The student worksheet based inquiry points that have been developed have three criteria for good worksheet recruitment, such as didactic, constructive, and technical requirements. The didactic requirement is being able to invite active students in the learning process, emphasizing the process of finding concepts, having a variety of stimulus through various media and student activities in accordance with the characteristics of the applied curriculum, developing social, emotional, moral and aesthetic communication skills in students, personal development goals determine learning experiences. The constructive requirements include the use of standard language, systematic vocabulary, and sentence composition so that the user can understand it, has the appropriate level of difficulty, has clear objectives and is useful as a source of information, and has an identity to facilitate assessment. While the technical requirements include written systematically and have an attractive appearance so that it fosters students' enthusiasm for learning. This result was in line with Nurhayati et al. (2014) that the assessment of the quality of worksheets are based on aspects of the evaluation of the writing approach, the truth, depth and breadth of the concept, the clarity of the sentence, language, assessment of learning outcomes, student activities, implementation, physical appearance.

On the other hand, the quality of inquiry-based student worksheets also looks excellent based on the assessment of students and teachers (Ozmen & Yildirim, 2005; Ristanto, 2011; Damayanti et al., 2012). Student worksheets based-inquiry can make students learn better by involving the student's mental processes and stimulate students' thinking skills. This is in line with the opinion of Hogan & Berkoits (2000) that the educational scientists suggested using inquiry-based learning for improving student learning activity by obtaining data, through asking questions and doing research in the knowledge construction process. Similarly, Abdi (2014) and Ristanto et al. (2017) add the purpose that of inquiry learning is used to teach a specific concept, fact or skill and leads the way to open inquiry where the student formulates his problem to investigate. Syatriana et al. (2013), Utomo, (2016) Sartono, et al., (2017) added that the design of instruction in learning becomes active learning.

The results of this study indicated that the involvement of inquiry processes in learning improved understanding of concepts and developed students' thinking abilities because in inquiry students were given problems and are required to solve the problem. In solving this problem participants will be more active both in discussing and looking for learning resources (Ristanto, 2011; Pratama, 2018). This is supported by Tukidi (2011), that inquiry is an effort intended to overcome the problem of students' boredom in learning in class which is quite useful because the learning process is student-centered.

CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the student worksheet based inquiry developed is feasible to use in learning because they declared as very valid with values of 3,70. The response of students and teachers was also very good with scores of 82,92% and 83,50%. The student worksheet based inquiry points that have been developed have three criteria for good worksheet recruitment, such as didactic, constructive, and technical requirements. Student worksheets based-inquiry can make students learn better by involving the student's mental processes and stimulate students' thinking skills.

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