

THE DEVELOPMENT OF STUDENT WORKSHEET INTEGRATED BY STEM APPROACH IN PLANT GROWTH AND DEVELOPMENT MATERIAL TO TRAIN BIO-ENTREPRENEURSHIP SKILLS

Irkham Mahmudi

Biology Education, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya

Email: irkhammahmudi16030204046@mhs.unesa.ac.id

Endang Susantini, Pramita Yakub

Biology Education, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya

Email: endangsusantini@unesa.ac.id , pramitayakub@unesa.ac.id

Abstract

The student worksheet based on Science, Technology, Engineering, and Mathematics / STEM approach was developed as an new teaching materials that can provide life experiences with the theme of biological entrepreneurship related to Wick hydroponics. This research aim was to produce student worksheets based on the STEM approach in plant growth and development material to train Bio-entrepreneurship skills in terms of theoretical and empirical feasibility. The development research used the 4D model started from define, design, develop, and disseminate. The research parameters measured from theoretical feasibility based on product validity, while empirical feasibility based on the results of the worksheet implementation in a small group of the 12th-grade student based on the level of Fry graph readability and the questionnaire responses. The results of the worksheet development on theoretical feasibility got a validity score of 3.65 with a very valid category. Empirical feasibility results based on the readability test at the 12th level, indicated that the information in the student worksheet was easily understood by 12th-grade students and got 95% of positive responses. This worksheet occupied the theoretical and empirical feasibility aspects so it was able to be used as an alternative teaching material developed using the STEM approach to trained students' Bio-entrepreneurship skills.

Keywords: Student's worksheet, Bio-entrepreneurship, plant growth and development, hydroponic *Wick*.

INTRODUCTION

The development of 12th-grade high school learning during this present time has increasingly opened and leads to improvement in life skills. Through regulation of the Indonesian Education Ministry 65th of 2013, study activities need to be directed so students have the skills to make scientific product requirements.

The suitable skills to be developed in 12th-grade high school education in entrepreneurship based on scientific studies and utilizing biology learning or called Bio-entrepreneurship. The Bio-entrepreneurship skills is suitable for 12th-grade because the learning activities compatible with constructivism theory which build the knowledge step by step and based on the experiences who has been done by the student (Pratiwi, 2018). Furthermore, the Bio-entrepreneurship skills matched with the high order thinking levels start by analyze, create, and evaluate the product that will be created (Acs, 2018).

The main factor of Bio-entrepreneurship skills must be trained for 12th-grade high school is to civilize entrepreneurial behavior started from a young age, so

students have an innovative mindset to producing a biology-themed product (Rukmana, 2020). The consequence is the teachers as "agents of change" can help develop new jobs that are innovative and aware of the potential of surrounding natural resources (Subekti, 2013).

One of the teaching materials that can be developed to train Bio-entrepreneurship skills is called by student worksheet (Utami, 2019). The learning activities using this learning material have been done many times, but Bio-entrepreneurship worksheet needs more varied and deeper development (Afanudin, 2019).

The urgency of learning using student worksheet to train Bio-entrepreneurship skills because it contains an instruction that guides learners to achieve learning objectives (Katriani, 2014). The student worksheet can enhance the student's manner in developing local potentials into a higher-selling, scientifically-based product (Anwar, 2012). Instructions need to use a suitable approach so that the objectives of learning are achieved properly (Putri, 2019).

A learning approach that can be used as instruction is the STEM (Science, Technology, Engineering, and Mathematic) approach. The four aspects of STEM are used by learners to identify problems and develop solutions based on scientific analysis, technological integration, skilled product development, and mathematical analyses to know how effective the product is produced (Beers, 2011). Therefore, STEM approach can be used as a learner's cornerstone to develop and increase the selling value of a scientific product.

The Efforts to train Bio-entrepreneurship skills with STEM approach integration by combining the wick system hydroponic cultivation activities because the process is relatively easy and the harvest can be seen in a short time (Fitria, 2019). Hydroponic cultivation activities were suitable for the concept of Bio-entrepreneurship, because the manufacturing of these products utilizes local natural resources and includes an analysis of four STEM aspects. Also, hydroponic can be adapted to 12th high-grade students based on competencies 3.1th and 4.1th that require learners' activities in analyzing the concept and factors that affect the growth development process.

The Learning activities that will be implemented using the STEM approach student worksheet start from the "science" aspect who students will analyze the factors that affect the growth and development of vegetable plants, "technology" trains students to utilize the wick system hydroponic technology, "engineering" trains students to implement the vegetable cultivation technologies, and "mathematic" will helps students to analyzes the financial analysis include break event point, payback period, unit sales price, and profits. The process is assessed with Bio-entrepreneurship indicators these are the analysis of problems based on scientific studies, product innovation, and analysis of sales results (Ács, 2018).

This study aims to describe the theoretical and empirical feasibility of the STEM approach student worksheet as an alternative to new teaching materials for practicing Bio-entrepreneurship skills for 12th-grade students.

METHOD

The research used a method that refers to the 4-D development model (define, design, develop, and disseminate) from Thiagarajan (1974). The product that has been developed is a STEM approach student's worksheet based on plant growth and development material to train Bio-entrepreneurship skills. The define and design stage was done in April 2020, the development phase was done in May 2020, and the disseminate stage

was implemented a limited small group of 12th-grade students from Senior High School 1 Magetan in June 2020.

The worksheet development aims to describe the theoretical and empirical feasibility of student's worksheet. Theoretical feasibility is the result of the validation from plant growth-development expert and biology teaching materials expert considering the presentation, content, and language based on the Likert Scale assessment in table 1.

Table.1 Likert Scale

Scale Score	Categories
4	Very Valid
3	Valid
2	Quite valid
1	Invalid

(Source: Sugiyono, 2016)

The average of the validation total value is used to determine the level of STEM approach student worksheet validity and can be implemented in the learning activities for the 12th-grade student if the score reaches $\geq 2,51$.

Empirical feasibility was obtained from the readability test based on implementing the worksheets in a small group of students using the Fry chart test sheet and the questionnaire responses by the Guttman Scale.

Table 2. Guttman Scale

Score	Responses
1	Agree
0	Disagree

(Source: Sugiyono, 2016)

The analysis of student responses has shown in positive percentage which calculates by the formula:

$$\text{Positive responses (\%)} = \frac{\sum \text{students choices "Agree"}}{\sum \text{students}} \times 100\%$$

The result from that calculation compared with the interpretation positive score criteria in table 3:

Table 3. Interpretation Positive Score Criteria

Score (%)	Interpretation Criteria
49 - 61	Ineffective
62 - 74	Quiet Effective
75 - 87	Effective
88 - 100	Very Effective

(Source: Sugiyono, 2016)

Based on the table 3, it's concluded if the STEM approach student's worksheet has a positive category when the percentages of the score reach rata-rata $\geq 75\%$.

RESULT AND DISCUSSION

The Profile of STEM Approach Student Worksheet

The student worksheet of STEM Approach is a learning material that is used by students contain concept

analysis activities and the factor of plant grow-development which is integrated into the STEM approach providing an entrepreneurship experience through the *Wick* hydroponic cultivation.

The construction of this student worksheet referred to the basic competence of 3.1, which is analyzing the material concept of plant grow-development and 4.1 requires the students' activity in analyzing the factor of plant grow-development. The indicators of *Bio-entrepreneurship* skills which are expected to be achieved are: analyzing the problems based on scientific research, product innovation, and analyzing the sales results (Acs, 2018).

This product contains two parts that are related and integrated by STEM approach. "Science" aspect with a basic competence of 3.1 is on the first STEM approach student worksheet named "The Learning Introductory of *Bio-entrepreneurship* through Concept Analyze and the Factor which Influences the Plant Growth-Development". This worksheet has several features that are in each learning stage (Figure 1). Those features are (1) Pre-learning at identifying the plant part, (2) an explanation of the aspect of STEM to ease the students understanding the instruction, (3) a website barcode of the plant growth video process which is scanned by *Scan Codic Barcode* application on the smartphone, (5) the article about conventional vegetable cultivation and a hydroponic to be analyzed the factor which needs to be looked at when applying the *Wick* hydroponic.

The benefit of the feature substitution is to ease the students' understanding of the content and the instruction on the first student worksheet, thus they can achieve the purpose of the learning based on the basic competences which have been defined (Sudarmin, 2019).



Figure 1. 1st STEM Approach Student's Worksheet: (a) front layout, (b). feature: the description of STEM aspect named "Science" and scan barcode website video of germination.

The second STEM approach student worksheet named "the Learning of the Plant Growth and Development in *Wick* System of Hydroponic Cultivation". The learning activity was started from "Technology" aspect with the planning product, "Engineering" designed the product, "Mathematic" analyzed the finance prediction, marketed the product, and evaluated the results of the product experiment. Those activities were assessed based on the *Bio-entrepreneurship* skills indicator: product innovation and analyzing the sales results.

The important point that caused the second worksheet as the first product on this research is the existence of the indication and the guide of how the students defined the *Wick* hydroponic that would be created; how the concept marketing was; the finance analyzing prediction contained the price of products, *break event point (BEP)*, the profits, and *payback period*; and the evaluation of the marketing results which was compared with the finance analyzing prediction (Figure 2 and 3). The values of the entrepreneurship should be available on the student worksheet as the first character in the learning of *Bio-entrepreneurship* (Sutiyanti, 2018).

Cek Analisis Keuangan

1. **Harga Produk perunit (HPU):**
 - Jumlahkan biaya pengeluaran perunit barang
 - Tentukan total HPU dengan mengalikan jumlah total barang dalam 1 instalasi: $HPU \times n$ (sayur) = Rp.
2. **Tentukan profit yang akan diambil, maksimal 40% dari HPU:**
 $HPU \times \text{profit} (\%) = \text{Rp.}$
3. **Tentukan Harga Jual Perproduk dengan menambahkan HPU dan profit**
 $HJU: HPU + \text{Profit} (\text{Rp}) = \text{Harga Jual Perproduk} (\text{Rp})$
4. **Akumulasi HJU (Rp) dengan total barang dalam 1 instalasi:**
 $HJU (\text{Rp}) \times n \text{ sayur} = \text{Rp.}$
5. **Tentukan Break Event Point (BEP) untuk 1 instalasi:**
 $HJU_x = HPU \text{ total} (\text{Rp}) + (\text{Profit} (\%) \times HPU \text{ total} (\text{Rp}))$
 $(\text{BEP}) \times HPU \text{ total} (\text{Rp}) + (\text{Profit} (\%) \times HPU \text{ total} (\text{Rp}))$
 $HJU (\text{Rp})$
6. **Tentukan Payback periode (PP)**
 $PP = HPU \text{ total} (\text{Rp}) : \text{BEP} (n)$

Mathematic

H. EVALUASI DAN REFLEKSI

a. Setelah proses pemasaran produk selesai, bandingkan hasil pemasaran dengan analisis prediksi keuangan Anda!

- Apakah penjualan bisa mencapai profit yang telah ditentukan?
 Jawab : Berdasarkan hasil penjualan hanya mendapat keuntungan Rp6.080 dan belum mencapai profit yang ditentukan yaitu sebesar Rp14.400.
- Berapa kali proses produksi agar modal Anda bisa kembali 100%?
 Jawab : Produksi harus dilakukan sebanyak 3 kali agar kami mendapatkan modal utuh kembali.
- Bagaimana kendala saat proses penjualan produk sayur?
 Jawab : Kendala terdapat pada waktu yang cukup singkat dalam kegiatan pemasaran, sehingga banyak produk yang belum terjual semua.
- Apakah terdapat faktor yang menghambat saat proses budidaya sayur menggunakan hidroponi sistem wick sehingga hasil produksi tidak maksimal? jelaskan kondisinya!
 Jawab : Tidak ada faktor pertumbuhan dan perkembangan tanaman yang menghambat proses budidaya karena kami selalu melakukan observasi dan perawatan setiap hari.
- Diskusikan dengan kelompok anda, bagaimana solusi agar proses produksi selanjutnya bisa memenuhi target profit? Hal apa saja yang harus diperhatikan?
 Jawab : Kegiatan pemasaran harus dipertimbangan dengan tepat durasi dan caranya, sehingga produk dapat habis terjual. Selain itu, kami akan mencoba pre-order (pesanan dahulu) agar produk bisa habis terjual dalam waktu yang telah ditentukan.

Figure 3. The Feature in the 2nd STEM Approach Student Worksheet: Evaluation and Reflection

The integration of STEM aspect which was in each stage and instruction implicated the students' activeness. The thing was supported by the utilization of *smartphones* and the internet to access the material and information by scanning the barcode, the instrument of hydroponic that were Total Dissolved Solution (TDS) meter, pH meter, and the utilization of social media in marketing the product of *Wick* system hydroponic. The purpose was to cause the individual to have skill in collaborating the resource to be created an entrepreneurship product with a theme of biology to complete the needs for nowadays with the tough competition (Pratiwi, 2018).

Theoretical Feasibility of STEM Approach Student Worksheet

The result of theoretical feasibility referred to score that have been done by validator expert and shown in Table 4.

Table 4. The Result of Validation Score

Numb	The Value Criteria	Average
A. Technical Requirement		
1	Cover page display	3,5
2	Inclusion of the group identity of Student Worksheet	4
3	Time allocation	4
4	The guide in using Student Worksheet	3,5
5	The purpose of the learning	4
6	Presentation of illustration pictures, the colors, and the layout of Student Worksheet	4
The Average of Technical Requirement Validity		3,83
B. Didactic Requirement		
1	Student worksheet activity based on 2013 Curriculum (Permendikbud Numb.63 in 2013)	4
2	Student worksheet activity based on basic competence of the plant growth development	3,5
3	Student worksheet suitability with a material concept of the plant growth development	4
4	Student Worksheet key answer	3,5
The Average of Didactic Requirement Validity		3,75
C. The Construction Requirement of Student Worksheet		
1	Language	3,5
2	The instruction sentence and information	2,5
The Average of Construction Student Worksheet Validity		3
D. STEM Aspect (Science, Technology, Engineering, Mathematic) and the Indicator of <i>Bio-entrepreneurship</i> Skills		
1	<i>Science</i> aspect, the indicator of <i>Bio-entrepreneurship</i> on the problem observation	4

Numb	The Value Criteria	Average
(Student Worksheet I)		
2	<i>Technology</i> aspect, the indicator of <i>Bio-entrepreneurship</i> on the product innovation (Student Worksheet II)	4
3	<i>Engineering</i> aspect, the indicator of <i>Bio-entrepreneurship</i> on the product innovation (Student Worksheet II)	4
4	<i>Mathematic</i> aspect, the indicator of <i>Bio-entrepreneurship</i> on analyzing the product result (Student Worksheet II)	4
The Average of STEM Aspect Validity and the Indicator of <i>Bio-entrepreneurship</i>		4
The Average of All Aspects		3,65

Based on the data on Table 4, it was perceived that the average of the value aspect of student worksheet achieved a score of 3,65 and it was stated very valid with a score achievement of >2,51 (Sugiyono, 2016).

The first aspect of Student Worksheet validity was a technical requirement. The average of this aspect was about 3,83 with a very valid category (Sugiyono, 2016). However, two components did not achieve a maximal score, they were cover page display and the guide in using the student worksheet. The cover page display was improved based on the suggestion with altering the title of the student worksheet should be "The Learning Introductory of *Bio-entrepreneurship* through Concept Analyze and the Factor which Influences the Plant Growth and Development" thus it more referred to the learning of *Bio-entrepreneurship* and reorganized the cover picture which represented the learning topic. While the size of symbols on guidelines needed to be zoomed so thus guide was more clear and easy to be understood by the students.

The cover and symbols which is revised has a purpose to build a perception of students' psychologies to be ready in using student worksheets, provides a preview of the plant growth and development material, and the preliminary concept about *Bio-entrepreneurship* like the making of *Wick* hydroponic (Hart, 2013). Depdiknas (2008) define the technical requirements if the content in the worksheet must be easy for students to understand. So that the revision has been done correctly in the cover, symbols, and the instruction sentences.

The second aspect is the didactic requirement, which consisted of the suitability of student worksheet activity with the 2013 curriculum and competences, the suitability of student worksheet content with the material concept, and the inclusion of student worksheet key answer. The average acquisition of validity score in this aspect was about 3,75 which was very valid with a note that it needed improvement for student worksheet key answer and needed to be added a reference from the

textbook source that was used by bachelor, therefore it was expected the key answer matched with the latest of plant growth and development material and more accurate (Duarte et al., 2015).

The third aspect was on the student worksheet construction requirement. The validity score average in this aspect was about 3 and very valid (Sugiyono, 2016). The instruction in student worksheet is created based on four disciplines of STEM thus it can led the students to create a product from biology learning material that precious (Putri, 2018). Some aspects which did not consistent yet from the assessment criteria needed to be improved, they were: (1) the using of an operational sentence into the guide of student worksheet, subchapter, and instruction, (2) the diction choice need to be noticed especially for the subject, (3) the using of "saudara" for senior high school students impressed quite formal, it was better to use "anda" or "kalian", (4) it needed to recheck the questions or instructions since there were several things that did not suitable yet on *Bahasa Indonesia*. The revision was done by the researcher to ease the students about perceive content, information, and the instructions on student worksheet. So it's made the learning more efficient and easy to understood (Utami, 2019).

The fourth aspect was the assessment of STEM student worksheet applying the indicator of Bio-entrepreneurship skills, which gained the validity score average of 4 that was very valid. It meant that all components have been suitable for assessment criteria that were on the validity page instrument. The applying of STEM assessments on student worksheets is suitable for the material of the plant growth and Bio-entrepreneurship indicator, thus the students can perceive the information and the instruction gradually (Abdelkarim, 2018).

Based on the worksheet development which has been validated, the learning activities in the Bio-entrepreneurship worksheet was compatible with constructivism theory which build the student's knowledge gradually used experiences who has been obtained during the learning activities. Moreover, the Bio-entrepreneurship skills matched with the aspect of high order thinking levels specifically in analyze, create, and evaluate the product that will be created (Acs, 2018).

The purpose of STEM aspect, the plant growth material, and Bio-entrepreneurship indicator was to provide provision like the first experience when starting entrepreneurship to utilize the natural resources, thus each individual ready to face the needs of the public after graduated from formal education (Chen, 2018). The development of student worksheet will provide a new alternative material thus the learning is more interactive,

interesting, and provide a profit knowledge to the students (Hoffmann, 2011).

Empirical Feasibility of STEM Approach Student Worksheet

The empirical feasibility of STEM approach student worksheet is an analysis based on reading scores based on Fry graphic when in the learning process and the response questionnaire after the learning process ended.

a) Readability Test

The reading test was analyzed from the Fry graphic test that was implemented by the students in three paragraphs samples based on student worksheets, start from reading in the beginning, middle, and in the ending.

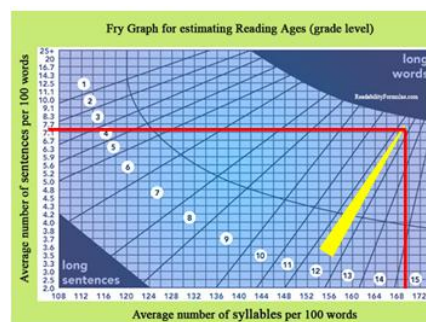


Figure 4. The result of the readability test at 12th level based on Fry chart from 1st and 2nd STEM approach student worksheet

The reading analysis referred to the level of students' facility in understanding the sentence that suitable based on the high senior class grade. The first student worksheet had a total sentence average of 7,3 which was gained on X pivot and syllables of 169 that was located on Y pivot of Fry graphic. The cut between both pivots was tangent to level 12, therefore the content in the first worksheet was categorized as easy to be understood for 12th-grade students. The second worksheet obtained the average number of sentences 7,5 on the X pivot and the syllables of 170 on the Y pivot. The pivot intersects exactly at level 12 and the information content is easily understood by 12th-grade students.

The STEM approach student worksheet was suitable and easy to be understood by the students since the content based on their grade (12th-grade students). The students were easy to understand the sentence because it was reviewed by the expert validators thus in the didactic requirement, the organizing of sentences gained a score in the average of 3 which was good. Besides that, the senior high school students can understand the complex

information, elaborate various information sources, and the analyzing level is well (Strachan, 2018).

b) The Effectiveness of STEM Approach Student Worksheet Based on Respond Questionnaires

The effectiveness was assessed based on the students' response questionnaire that contained student worksheet response which was expanded whether from in terms of appearance that attracts learning interest or abilities that can be mastered after carrying out a series of activities in there. The results of the response questionnaire can be seen in table 5.

Table 5. The Result of Response Questionnaires Based on STEM Approach Student Worksheet.

Nu mb	Bio-entrepreneurship Content	Student Responses (%)
1	The display, explication sentences, and Student Worksheet content.	97%
The 1st STEM Approach Student Worksheet		
2	The analyzing concept activity and the factor of the plant growth based on article and video.	94,1%
The 2nd STEM Approach Student Worksheet		
3	Planning the Wick hydroponic product.	94,1
4	Creating an installation of Wick hydroponic.	100
5	Analyzing the price of a unit, the break event point, the advantage, and the payback period.	100
6	Marketing Wick Hydroponic Product.	100
7	Evaluating marketing results based on finance analyzing.	94,1
Total Score		97%

The learning activities carried out using STEM approach student worksheet were considered to be very effective started from analyzing the factors affecting the growth of vegetable plants (*Science*), training students to utilize hydroponic technology (*Technology*), training to test vegetable cultivation technology (*Engineering*) and analyzing break event points, the payback period, the sales price of the unit, and the profits obtained (*Mathematic*). This is shown by the positive responses of students in all aspects of the assessment table 5 learning responses using the worksheet reaching a percentage of 95% with a very effective category (Sugiyono, 2016).

Patchen (2017) explained if teaching materials can help achieve learning objectives if the content and instructions in there can be done by students well so that they feel the benefit following the learning themes.

Beers (2011) explained if the aspects of STEM are used by students in identifying problems and developing solutions based on scientific studies, technology integration, skilled product development, and mathematical analysis to find out how effective the resulting product is. Therefore, the students are expected to be more motivated to participate in learning and understanding the concepts of competencies 3.1 and 4.1 that require learners' activities in analyzing the factors that influence plant growth and development.

The analysis of all aspects outlined above explained that the worksheets were empirically feasible and can be used as an alternative for new teaching materials that can train the entrepreneurial skills of 12th-grade students.

CONCLUSION

The development of teaching materials produced two variants of the worksheet, the first one of STEM approach student worksheet named "The Learning Introductory of *Bio-entrepreneurship* through Concept Analyze and the Factor which Influences the Plant Growth and Development" and the second worksheet "The Learning of the Plant Growth and Development in *Wick* System of Hydroponic Cultivation". The developed student worksheet was declared valid and theoretically feasible with a validity score of 3.65, a very good category. The application of student worksheets in the small group of 12th-grade students was declared empirically feasible with a level of readability of 12 and the response of the students was very effective at 95%.

SUGGESTION

The learning of developmental growth material using STEM approach student worksheet was successfully carried out in small groups. The application of these products needs to be done in classes with the appropriate amount so that the skills of Bio-entrepreneurship and hydroponic vegetable cultivation of the Wick system can be felt by many students.

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