



# PROCEEDINGS OF THE 8<sup>th</sup> INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION AND EDUCATION OF MATHEMATICS AND SCIENCES (8<sup>th</sup> ICRIEMS)



“Transforming Science Literacy into  
A New Normal Digital World to Achieve  
Sustainable Development Goals”



Yogyakarta: August 27<sup>th</sup>-28<sup>th</sup>, 2021

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FMIPA UNIVERSITAS NEGERI YOGYAKARTA

**Proceedings of the 8<sup>th</sup> International Conference on Research, Implementation and Education of Mathematics and Sciences (8<sup>th</sup> ICRIEMS): Transforming Science Literacy into A New Normal Digital World to Achieve Sustainable Development Goals**

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## Preface

This proceeding is the regular edition (non-Scopus-indexed) of the conference proceedings of the 8<sup>th</sup> International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS) held by the Faculty of Mathematics and Science, Yogyakarta State University, Indonesia on 27<sup>th</sup>-28<sup>th</sup> August 2021 at Yogyakarta State University. All papers in this proceeding were obtained from a selection process by a team of reviewers and had already been presented in the conference. Some selected papers from the conference were compiled under separate proceedings and published by American Institute of Physics (AIP) Conference Proceeding which is Scopus-indexed. This proceeding comprises 9 fields, they are mathematics, mathematics education, physics, physics education, chemistry, chemistry education, biology, biology education, and science education.

The theme of this 8<sup>th</sup> ICRIEMS is '*Transforming Science Literacy into A New Normal Digital World to Achieve Sustainable Development Goals*'. This conference presented four keynote speakers, which were Prof. Dr. Vincentas Lamanuskas (Vilnius University Šialiai Academy, Institute of Education, Lithuania), Dr. ir. W. T. van Horssen (Electrical Engineering, Mathematics and Computer Science, Delft Institute of Applied Mathematics), Dr. Syarif Riyadi (Energi Academy Indonesia (ECADIN), Prof. Dr. Paidi (Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Indonesia). Besides the keynote speakers, there were also parallel articles that present the latest research results in the field of mathematics, sciences, and education. These parallel session speakers came from researchers from Indonesia and abroad.

Hopefully, this proceeding may contribute in disseminating research results and studies in the field of mathematics, sciences and education such that they are accessible by many people and useful for the development of our civilization.

Yogyakarta, December 2021

Editorial Team

## Forewords from the 8th ICRIEMS Chairman

The International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS) is annual event organized by Faculty of Mathematics and Science, Universitas Negeri Yogyakarta, Indonesia. Covid-19 pandemic has challenged all aspects of human life and setback the sustainable development goals. Therefore, this year, the 8<sup>th</sup> ICRIEMS, has been successfully held on August 27<sup>th</sup> – 28<sup>th</sup>, 2021 with the theme of **“Transforming Science Literacy into A New Normal Digital World to Achieve Sustainable Development Goals”**.

The conference is an event where prominent students, educators, researchers, and practitioners from all around the world are joining together to share their latest research and exchange their ideas. This proceeding is a compilation of how academicians and researchers in Indonesia (and ASEAN) contribute to the challenges due to Covid-19 pandemic, focused on how to transform science literacy in the field of mathematics and natural (educational) sciences through their research to achieve the sustainable development goals. Special topics areas include sustainable nano materials development, potencies of natural compounds and biodiversity, data science for SDGs, and how the teaching and learning of science education adopt the Covid-19 pandemic challenges and reshape based on digital platform.

The conference has been a good place to promote or maintain not only national but also international collaboration and networking among academics, researchers, and educators. The conference has accepted and selected 80 papers from Indonesia, Malaysia, and Thailand that are published by AIP Publisher under Scopus Index.

We owe special thanks to our keynote and invited speakers:

Keynote speakers:

1. Dr. Vincentas Lamanauskas – Vilnius University Šialiai Academy, Institute of Education, Lithuania
2. Dr. ir. W. T. van Horssen – Electrical Engineering, Mathematics and Computer Science, Delft Institute of Applied Mathematics
3. Dr. Syarif Riyadi – Energi Academy Indonesia (ECADIN)
4. Dr. Paidi – Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Indonesia

Invited speakers:

1. Dr. Sri Wahyuni, S. Pd., M.Pd. – Universitas Jember, Indonesia
2. dr. Dian Kesuma Pramudya Nurputra, Ph.D., M.Sc., Sp.A – Faculty of Medicine, Public Health and Nursing, Gadjah Mada University

Last but not least, we address very big appreciation and many thanks to all presenters and participants who have been actively involved in this conference. We also wish to thank to our reviewers for invaluable comments and suggestions.

Nur Aeni Ariyanti  
Kartika Ratna Pertiwi  
Heru Sukoco  
Fika Fauzi  
Paramita Cahyaningrum Kuswandi

**VIRTUAL CONFERENCE PROGRAM**  
**THE 8<sup>th</sup> INTERNATIONAL CONFERENCE ON RESEARCH,**  
**IMPLEMENTATION & EDUCATION**  
**OF MATHEMATICS AND SCIENCES (ICRIEMS) 2021**  
**27<sup>th</sup>-28<sup>th</sup> August 2021, UNIVERSITAS NEGERI YOGYAKARTA, INDONESIA**  
Friday, August 27<sup>th</sup>, 2021

No	Time	Programs
1	06.30 - 06.45	Registration
2	06.45 - 07.00	Opening
		1. National Anthem
		2. Welcome speech: Chairman of ICRIEMS 2021
		3. Opening Conference by Rector of UNY
3	07.00 – 11.00	Keynote speech #1: Prof. Dr. Paidi, M. Si. (Faculty of Mathematics and Natural Sciences, UNY)
4	11.00 - 12.30	Break
5	12.30 - 16.30	Keynote speech #2: Prof. Dr. Vincentas Lamanuskas (Vilnius University Siauliai Academy, Institute of Education, Lithuania)
6	16.30 - 17.00	Break
7	17.00 – 21.00	Keynote speech #3: Dr. Ir. W.T. Van Horssen (Electrical Engineering, Mathematics and Computer Science Delft Institute of Applied Mathematics)
8	21.00 - 21.15	Closing

**VIRTUAL CONFERENCE PROGRAM**  
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**27<sup>th</sup>-28<sup>th</sup> August 2021, UNIVERSITAS NEGERI YOGYAKARTA, INDONESIA**  
 Saturday, August 28<sup>th</sup>, 2021

No	Time	Programs
1	07.30 - 07.45	Opening
2	07.45 - 11.45	Keynote Speech #2 Dr. Syarif Riyadi (Energy Academy Indonesia (ECADIN), Supply Chain Defectivity Expert in Semiconductor Industry)
3	11.45 - 12.15	Break
4	12.15 - 14.45	Invited speakers #1 Dr. Dian Kesuma Pramudya Nurputra, Ph.D., M.Sc., Sp.A (Faculty of Medicine, Public Health, and Nursing, UGM)
		Invited speakers #2 Dr. Sri Wahyuni, S.Pd., M.Pd. (Universitas Jember, Indonesia)
5	14.45 - 17.45	Parallel sessions
6	17.45 - 18.00	Closing Best presenter award

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# The Inventory of Moss at The Nglanggeran Ancient Volcano Area, Gunung Kidul, Yogyakarta.

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**Abstract.** The research aims to inventorize the variation of mosses at the Nglanggeran Ancient Volcano area, Patuk, Gunungkidul. This research is an observational qualitative research by collecting and identifying all mosses found in the Nglanggeran Ancient Volcano (AV) area. The sampling technique is an explore method, by taking samples along the tracking path in the Nglanggeran AV. Every moss found was identified and photo-documented. Then the samples were taken for microscopic observation of its taxonomic features in the laboratory. Microscopic observations were carried out in the laboratory of the Department of Biology Education, Faculty of Mathematics and Sciences, Yogyakarta State University. The research was conducted from March to May 2021. The results showed that there are 23 species of mosses. From those species, there are 2 species of Marchantiopsida, 2 species of Jungermanniopsida, 1 species of Anthocerotopsida, and 18 species of Bryopsida. In addition, there were 9 types of mosses identified up to the genus level and 14 types of mosses identified up to the species level.

## INTRODUCTION

Mosses are the second most diverse terrestrial plant phylum in the world with about 13,000 species [1]. In Indonesia, one of the plants with a high level of species diversity is moss. There are about 1,500 species of moss plants spread across various regions in Indonesia [2]. However, moss is one type of plants that has not been widely studied and considered unattractive. It is even commonly seen as the cause where surrounding environments become dirty. Nevertheless, if it is observed carefully, it is quite interesting, in terms of color or shape where it lives in groups like a green rug that make the forest floor look beautiful [3].

Moss is a low-level plant that lives in damp or wet places [4]. They are often found living in groups and attached to substrates, such as soil, rocks, tree bark, and others [5]. The size of the moss is relatively small with a height of about 1-2 cm, even the largest moss only has a height of less than 20 cm [6]. The grouping of moss is divided into 3 divisions; liverworts (Liverwort/Hepatophyta), hornworts (Hornwort/Anthocerophyta), and leaf mosses (Moss/Bryophyta) [7].

Moss has many benefits for the environment. It is a pioneer plant that can grow for the first time in an environment that has been damaged [8]. It can be a good germination medium for other plant seeds because mosses have the ability to hold water (water holding capacity) [4]. They are also a habitat for other organisms such as invertebrate and several types of orchids [9].

The Nglanggeran AV area has a lithology composed of old volcanic material and thus, it is geologically very unique and has a high scientific value [10]. It becomes one of the places that has various types of moss. The Nglanggeran AV is a well-known ecotourism located on the Nglanggeran Village, Patuk, Gunung Kidul, Yogyakarta. It was active about 60 million years ago, and it is located at an altitude of 700 m above the sea level [10]. One of the uniqueness of the Nglanggeran AV is that there is a collection of highlands that rises in only one area [11]. Also, the plains are composed of old rocks formed from volcanic activity millions of years ago, not composed of limestone like in another of the Gunungkidul area.

The research aims to inventorize the variation of mosses at the Nglanggeran Ancient Volcano area, Patuk, Gunungkidul.

## METHODOLOGY

This research was held in from March to May 2021 at the Nglanggeran AV, Nglanggeran Village, Patuk, Gunungkidul Regency, Yogyakarta Special Region Province, whereby data collection on various samples of moss plant species were taken. Microscopic observation of the morphological structure of the moss was carried out at the Biology Laboratory, Faculty of Mathematics and Natural Sciences, YSU.

The data collection technique was an exploration method, based on the tracking route of Nglanggeran AV (Figure 1). Explorations were carried out at the research location which had a fairly steep geography and many high rock cliffs, in order to find moss in the mountain area.



FIGURE 1. Hiking trail map of ancient volcano Nglanggeran

All of the moss found was photographed and its visible morphological characteristics were recorded. Then the moss plants were taken together with the substrate as samples in a labeled ziplock plastic/bottle. The samples were then preserved using a 70% alcohol solution. The samples were observed under a microscope to see microscopic morphological characteristics for the identification process and were documented with a camera. After completion, identification of moss plants is carried out by conducting a literature study using moss identification books and the other reference sources.

## RESULTS AND DISCUSSION

Research on mosses in Nglanggeran AV found 23 species. Various types of mosses were found including the group of leaf mosses, thallus and leafy liverworts and hornworts. The types of mosses found in the Nglanggeran AV area can be seen in the following table:

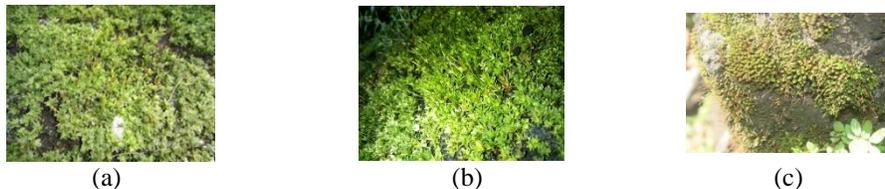
**TABLE 1.** Types of Moss Plants in the Nglanggeran AV area

No.	Class	Species
1.	Marchantiopsida	<i>Marchantia</i> sp.
2.	Marchantiopsida	<i>Riccia</i> sp.
3.	Jungermanniopsida	<i>Fossombronia japonica</i>
4.	Jungermanniopsida	<i>Jungermannia</i> sp.
5.	Anthocerotopsida	<i>Anthoceros</i> sp.
6.	Bryopsida	<i>Bryum</i> sp. (S12)
7.	Bryopsida	<i>Bryum</i> sp. (S28)
8.	Bryopsida	<i>Calymperes afzelii</i>
9.	Bryopsida	<i>Campylopus introflexus</i>
10.	Bryopsida	<i>Campylopus umbellatus</i>
11.	Bryopsida	<i>Ceratodon purpureus</i>
12.	Bryopsida	<i>Erythrodontium julaceum</i>
13.	Bryopsida	<i>Fissidens</i> sp.
14.	Bryopsida	<i>Fissidens osmundioides</i>
15.	Bryopsida	<i>Hyophila involuta</i>
16.	Bryopsida	<i>Hyophila</i> sp.
17.	Bryopsida	<i>Hypnum plumaeforme</i>
18.	Bryopsida	<i>Octoblepharum albidum</i>
19.	Bryopsida	<i>Philonotis hastata</i>
20.	Bryopsida	<i>Philonotis</i> sp.
21.	Bryopsida	<i>Plagiothecium laetum</i>
22.	Bryopsida	<i>Plagiothecium succulentum</i>
23.	Bryopsida	<i>Tortella tortuosa</i>

### Types of Moss Plant in the Nglanggeran AV Area

#### 1. Family Pottiaceae

The study found 2 genera: *Hyophila involuta*, *Hyophila* sp. and *Tortella tortuosa*.



**FIGURE 2.** Colonies of (a) *Hyophila involuta* (b) *Hyophila* sp. (c) *Tortella tortuosa* in habitat.

##### a. *Hyophila involuta*

Classification *Hyophila involuta*

Kingdom : Plantae  
 Division : Bryophyta  
 Class : Bryopsida  
 Order : Pottiales  
 Family : Pottiaceae  
 Genus : *Hyophila*  
 Spesies : *Hyophila involuta* (Hook.) A. Jaeger

*Hyophila involuta* has a green yellowish leaf, lanceolate shape with a pointed tip and jagged edges. In the middle of the leaf, there is a costa that extends from the base to the top (percurrent) [12]. The top of the leaf arrangement

spreads around the stem like a rose shape. The leaf length is 0.2-0.4 mm. The stem is erect with a brownish-green color. Thin red rhizoids are located at the lower end of the plant. The seta is about 0.8-1 cm long with a green color. Green capsule with a cylindrical shape. The calyptra is shaped like a hood (cucullate). Capsule lids like cone-shaped with a long tip. Spores are round. This species is found growing attached to rocks and damp cement walls.

b. *Hyophila* sp.

Classification of *Hyophila* sp

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Pottiales  
Family : Pottiaceae  
Genus : *Hyophila*  
Species : *Hyophila* sp.

*Hyophila* sp. have stems that grow upright. The leaves are lanceolate in shape (oblong-lanceolate) with small toothed edges (denticulate) at the ends, the veins are along with the leaf from bottom to top (percurrent) The roots are at the base of the body reddish. The capsules are cylindrical, green to brownish green when ripe, there is no peristome, equipped with calyptra in the form of cucullate. This moss is found on rock substrates.

c. *Tortella tortuosa*.

Classification of *Tortella tortuosa*

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Pottiales  
Family : Pottiaceae  
Genus : *Tortella*  
Species : *Tortella tortuosa*

*Tortella tortuosa* has a green phylloid, linear phylloid shape with a pointed tip, a small wavy edge, and a prominent costa extending from the base to the top (excurrent) [13]. The arrangement of phylloids around each other stems. Filoids extend up to 0.1-0.2 mm. Upright cauloid with green color. Red short rhizoids are located at the lower end of the plant. Seta length of about 1.1 cm. Kaliptra is reddish-orange in color with a pointed campanulate shape. Green cylindrical capsule. Spores are round. Grows attached to the rock.

## 2. Family Ditrichaceae

The study found 1 genus: *Ceratodon purpureus*.



**FIGURE 3.** Colonies of *Ceratodon purpureus* in habitat.

Classification of *C. purpureus*

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Dicranales  
Family : Ditrichaceae  
Genus : *Ceratodon*  
Species : *Ceratodon purpureus* var. *rotundifolius* (Hedw.) Brid

*Ceratodon purpureus* has a dark green leaf, oval lanceolate-shaped with a pointed tip, slightly jagged apex, and costa extending from the base to the top (excurrent) [14]. The upper phylloid arrangement spreads around the stem. The phylloid extends up to 0.2-0.3 mm. Upright cauloid with green color. Thin brownish rhizoids are located at the lower end of the plant. Seta erects with a length of 1.5 cm with a red color. Red color capsule with a cylindrical shape. The capsule lid is shaped like a cone (conical). No peristome. Spores are round. Grows attached to the rock.

### 3. Family Bartramiaceae

The study found 2 species in 1 genus: *Philonotis hastata* and *Philonotis sp.*

#### a. *Philonotis hastata*



**FIGURE 4.** Colonies of (a) *Philonotis hastata* (b) *Philonotis sp.* in habitat

Classification of *Philonotis hastata* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Bartramiiales  
Family : Bartramiaceae  
Genus : *Philonotis*  
Species : *Philonotis hastata* Wijk & Margadant, 1959

*Philonotis hastata* has a bright green phylloid, lanceolate/lance-like phylloid shape, and tapering from near the tip of the base [15]. The phylloid edges are serrated and the ribs extend from base to apex (percurrent). The upper phylloid arrangement spreads around the stem. Filoid extends up to 0.1 mm. Upright Kauloid with brown color. Thin red rhizoids are located at the lower end of the plant. No sporophyte phase was found at the time of observation. Moss clings to rocks.

#### b. *Philonotis sp.*

Classification of *Philonotis sp.* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Bartramiiales  
Family : Bartramiaceae  
Genus : *Philonotis*  
Species : *Philonotis sp.*

*Philonotis sp.* has green, needle shape, tight, jagged edges and sharp ends phylloid, costas are not clear. The leaves arrangement surrounds the stem and is tightly packed. Leaf extends up to 0.1 mm. Brownish cauloids. Thin red-brown rhizoid located at the lower end of the plant, rhizoid looks tumentose or dreadlocks [14]. In this species, no sporophyte phase was found during observation. Moss clings to a rock substrate.

### 4. Family Hypnaceae

The study found 1 genus: *Hypnum plumaeforme*



**FIGURE 5.** Colonies of *Hypnum plumaeforme* in habitat.

Classification of *Hypnum plumaeforme* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Hypnales

Family : Hypnaceae  
Genus : Hypnum  
Species : *Hypnum plumaeforme* Wilson, 1848

*Hypnum plumaeforme* has a yellowish-green phylloid, an ovoid-shaped with a pointed tip, flat edges, and indistinct costa. Alternating phylloid arrangement spiral ascending (alternate). Leaf extends up to 0.1 mm, green. The long stem, many branches, and creeping/spreading plants can thus support this species to live as an epiphyte in rocks/plants [16]. Thin reddish-brown rhizoids are located at the lower end of the plant. There is no sporophyte phase at the time of observation. This plant is attached to the rock.

#### 5. Family Plagiotheciaceae

The study found two species in one genus: *Plagiothecium laetum* and *Plagiothecium succulentum*.



**FIGURE 6.** Colonies of (a) *Plagiothecium laetum* (b) *Plagiothecium succulentum* in habitat

##### a. *Plagiothecium laetum*

Classification of *Plagiothecium laetum* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Hypnales  
Family : Plagiotheciaceae  
Genus : Plagiothecium  
Species : *Plagiothecium laetum*

This species is light green to yellowish in color and looks shiny. The stems are spread with leaves arranged complanate, the stem length is about 1-3 cm. The leaves are oval-oblong, slightly concave, tapering to the tip of the leaf or apiculate, the base of the leaf is decurrent, with entire leaf margins, has short and double ribs, the leaf cells are rectangular (rectangular). The seta of this species is about 10-15 mm long, reddish in color with an erect capsule measuring about 1-1.5 mm. The roots are found in the old stem segments. *Plagiothecium laetum* is found growing on rock substrates.

##### b. *Plagiothecium succulentum*

Classification of *Plagiothecium succulentum* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Hypnales  
Family : Plagiotheciaceae  
Genus : Plagiothecium  
Species : *Plagiothecium succulentum*

This species is dark green and shiny. The stems are horizontal on the substrate. The leaves are more or less symmetrical, oval-lanceolate, concave, serrated at the tips of the leaves. Leaf cells are thin-walled, linear to vermicular in shape. The roots of this species are reddish in color. This species is found on moist rocky substrates.

#### 6. Family Dicranaceae

The study found one species: *Campylopus introflexus*



**FIGURE 7.** Colonies of *Campylopus introflexus* in habitat.

Classification of *Campylopus introflexus* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Dicranales  
Family : Dicranaceae  
Genus : Campylopus  
Species : *Campylopus introflexus* Bridel, 1819

*Campylopus introflexus* has a green phylloid, upright phylloid, linear/oval-shaped [14]. Filoid with a pointed tip, jagged edges, and costa extending from base to apex (percurrent). The arrangement of phylloid around each other stems. The leaves extend up to 0.3-0.4 mm. Upright stems with green color. Red short rhizoids are located at the lower end of the plant. No sporophyte phase was found during observation. Moss clings to rocks.

#### 7. Family Entodontaceae

The study found one species of this Family: *Erythrodontium julaceum*



**FIGURE 8.** Colonies of *Erythrodontium julaceum* in habitat.

Classification of *Erythrodontium julaceum* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Hypnales  
Family : Entodontaceae  
Genus : Erythrodontium  
Species : *Erythrodontium julaceum*

*Erythrodontium julaceum* golden green to brownish, strong, stiff, and shiny. The main stem is a vine, the secondary branches are many and erect. The leaves are arranged in chock and piled (julaceous), dense and erect. The leaves are ovate (ovoid), slightly concave, the tip of the leaf is pointed or tapered (acuminate), the leaf edge is smooth, slightly serrated at the tip of the leaf, there is no costa (ecostate). Cells and thin-walled, elliptical to linear at the tip of the leaf, while the inside of the cell is elongated and rhomboid in shape. The seta is erect, sometimes slightly curved, spiraling when dry. The capsule is erect, oval-cylindrical, reddish in color, equipped with a conical operculum, cucullate calypso covering more than half of the capsule, with a double peristome. The spores of this species are papillary rough on the surface. This species is found on rocky substrates that are sufficiently water or moist.

#### 8. Family Calymperaceae

The study found one species: *Calymperes afzelii*



**FIGURE 9.** Colonies of *Calymperes afzelii* in habitat.

Classification of *Calymperes afzelii* is:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Calymperales  
Family : Calymperaceae  
Genus : Calymperes  
Species : *Calymperes afzelii*

*Calymperes afzelii* has green leaves, a lanceolate phylloid shape with blunt ends, flat edges, and ribs extending from base to apex (mucronate). At the end of the leaf tip, there is a gemma. Gemma is generally adaxial at the end of the leaf edges that roll up to hug the costa [17]. Rosette phylloid arrangement. The leaves extend up to 0.2 mm., in green color. Thin red rhizoids are located at the lower end of the plant. No sporophyte phase was found.

**9. Family Bryaceae**

The found two species of Byum: *Bryum* sp. and *Bryum* sp.



(a)



(b)

**FIGURE 10.** Colonies of (a) *Bryum* sp. (b) *Bryum* sp. in habitat.

a. *Bryum* sp.

Classification of *Bryum* sp. is:

Kingdom : Plantae  
 Division : Bryophyta  
 Class : Bryopsida  
 Order : Bryales  
 Family : Bryaceae  
 Genus : Bryum  
 Species : *Bryum* sp.

*Bryum* sp. has a green phylloid, lanceolate phylloid shape with a pointed tip, jagged edges, and ribs extending from the base to the top (excurrent). The arrangement of phylloid around the stem (spiral) [18]. The phylloid extends up to 0.2-0.3 mm. Cauloids are erect with a brownish-green color. Short rhizoids of pale brown color are located at the lower end of the plant. Red long set. cylindrical capsule, pyriform with colors there is green and brown. Red-brown calyptra shaped like a cone (conical). Spores rounded.

b. *Bryum* sp.

Classification of *Bryum* sp. is:

Kingdom : Plantae  
 Division : Bryophyta  
 Class : Bryopsida  
 Order : Bryales  
 Family : Bryaceae  
 Genus : Bryum  
 Species : *Bryum* sp.

The leaves are green, lanceolate phylloid shape with a pointed tip, flat edge, and ribs extending from the base to the top slightly (cuspidate). The arrangement of leaves around each other is a rod/spiral [18]. The phylloid extends up to 0.2-0.3 mm. Cauloids are erect with a brownish-green color. Short rhizoids of pale brown color are located at the lower end of the plant. No sporophyte phase was found. Grows attached to the rock.

**10. Family Leucobryaceae**

The study found one species: *Campylopus umbellatus*



**FIGURE 11.** Colonies of *Campylopus umbellatus* in habitat.

Classification of *Campylopus umbellatus* is:

Kingdom : Plantae  
 Division : Bryophyta  
 Class : Bryopsida  
 Order : Dicranales  
 Family : Leucobryaceae

Genus : *Campylopus*  
Species : *Campylopus umbellatus*

This species is on the top yellowish-green, and green-yellowish brown on the underside, shiny. Stems erect, sterile plants have many leaves that are clustered, and spread at the top, like a tail. The leaves are arranged upright (erect), lanceolate, smooth edges (entry), and toothed at the tips of the leaves. Leaf bones occupy 1/3 of the width of the leaf base. Leaf cells are oval to rhombic, thick-walled at the tip of the leaf. The basal leaf cells are rectangular in shape, wide, and getting narrower to the edge of the cell. The alar leaf cells form like an auricle, bulging and reddish-brown in color. Roots are at the base of the body, reddish-brown. This species includes plants dioicous. The moss found in moist and wet soil.

#### 11. Family Leucophanaceae

The study found one species: *Octoblepharum albidum*



FIGURE 12. Colonies of *Octoblepharum albidum* in habitat.

Classification of *Octoblepharum albidum* is :

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Dicranales  
Family : Leucophanaceae  
Genus : Octoblepharum  
Species : *Octoblepharum albidum*

*Octoblepharum albidum* whitish green. The leaves are stacked, arranged upright spread on a very short stem. The leaves are ribbon-shaped (*lingulate*) which is about 3-5 mm long, leaf tips apiculate. The roots are on the underside of the body reddish-brown. The erect seta is yellowish in color with a length of about 5 mm. The capsule is erect, ovoid-cylindrical (*ovoid-cylindric*), dark green, and brown when ripe. The capsule is equipped with a peristome of 8 pairs of teeth. calyptra-shaped is *cucullated*. Spores are round with *papillae* (protrusion) smooth on the surface. This species is found growing attached to the trunks of palm trees.

#### 12. Family Fissidentaceae

The study found two species of genus *Fissides*: *Fissides osmundioides* and *Fissidens* sp.



(a)



(b)

FIGURE 13. Colonies of (a) *Fissides osmundioides* (b) *Fissidens* sp. in habitat.

a. *Fissides osmundioides*

Classification *Fissides osmundioides*:

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Fissidentales  
Family : Fissidentaceae  
Genus : Fissidens  
Species : *Fissides osmundioides* Hedw. (TSN 16903)

*Fissides osmundioides* has a bright green phylloid at the tip and dark at the bottom, a lanceolate phylloid shape with a pointed tip, flat edges, and costa extending from the base to the top (percurrent) [14]. The arrangement of phylloid opposite each other, arranged in 2 rows (distichous) and meeting. Filoid extends up to 0.1 mm. In the phylloid, there is a sheathing lamina which is located above the phylloid. Upright stem with brown color. Red short

rhizoids are located at the lower end of the plant. Short seta about 0.2-0.3 mm green color. Green, cylindrical capsule. The calyptra is shaped like a beak (rostrate). Spores are round. Plants cling to the most rock.

b. *Fissidens* sp.

Classification *Fissidens* sp. is :

Kingdom : Plantae  
Division : Bryophyta  
Class : Bryopsida  
Order : Fissidentales  
Family : Fissidentaceae  
Genus : Fissidens  
Species : *Fissidens* sp.

*Fissidens* sp. have dark green leaves, lanceolate-shaped with a pointed tip, jagged edges and costa extending from the base to the top (percurrent), and wide costa, narrow apical leaf base [19]. The arrangement of phylloids opposite each other, arranged in 2 rows (distichouse) and meeting. The leaves extend up to 0.1 mm. In the leaf, there is a sheathing lamina which is located above the phylloid. Upright stem browned color. Red short rhizoids are located at the lower end of the plant. Short seta about 0.2-0.3 mm green color. Cylindrical capsule with green color. The calyptra is shaped like a beak (rostrate). Plants cling to the most rock.

**13. Family Anthocerotaceae**

The results of the study found 1 genus, namely: *Anthoceros* sp.



**FIGURE 14.** Colonies of *Anthoceros* sp. in habitat.

Classification of *Anthoceros* sp. is :

Kingdom : Plantae  
Division : Anthocerotophyta  
Class : Anthocerotopsida  
Order : Anthocerotales  
Family : Anthocerotaceae  
Genus : Anthoceros  
Species : *Anthoceros* sp.

Thalli of this species are concave and grow in the form of rosettes with a diameter of about 1-3 cm and are dark green in color. The thalli are irregularly divided into lobes with wavy edges. Smooth roots are on the dorsal thalli. The capsule is cylindrical in shape with a length of about 2-3 cm. The spores are polar, blackish-brown in color, the trilete sign is not visible, the distal part contains many spines [14]. This species is found on rock substrates.

**14. Family Ricciaceae**

The study found one species: *Riccia* sp.



**FIGURE 15.** Colonies of *Riccia* sp. in habitat.

Classification of *Riccia* sp. is:

Kingdom : Plantae  
Division : Marchantiophyta  
Class : Marchantiopsida  
Order : Marchantiales  
Family : Ricciaceae  
Genus : Riccia  
Species : *Riccia* sp.

*Riccia* sp. has a bright and dark green thallus, ribbon-shaped with. On the surface looks shiny and there are lines. The thallus has flat edges and forms an incomplete rosette branching [20]. The rhizoid is very soft and thin. No sporophyte phase was found at the time of observation. Moss clings to a rock.

#### 15. Family Marchantiaceae

The results of the study found one species: *Marchantia* sp.



FIGURE 16. Colonies of *Marchantia* sp. in habitat.

Classification of *Marchantia* sp. is:

Kingdom : Plantae  
Division : Marchantiophyta  
Class : Marchantiopsida  
Order : Marchantiales  
Family : Marchantiaceae  
Genus : *Marchantia*  
Species : *Marchantia* sp.

The body shape of this species is thallus with furcate branches. The edges of the thallus are wavy (sinuose). The thallus is glossy green. On the upper surface of the thallus, there is a slightly protruding circular external pore, surrounded by two thin-walled stratified rings, and a narrower internal pore surrounded by 2-3 rings. The rhizoid is on the dorsal reddish brown. There is a female receptacle with a short stalk at the end of the lobe. This species is found living in moist soil substrates.

#### 16. Family Jungermanniaceae

The study found one species *Jungermannia* sp.



FIGURE 17. Colonies of *Jungermannia* sp. in habitat

Classification of *Jungermannia* sp. is:

Kingdom : Plantae  
Division : Marchantiophyta  
Class : Jungermanniopsida  
Order : Jungermanniales  
Family : Jungermanniaceae  
Genus : *Jungermannia*  
Species : *Jungermannia* sp.

This species is green to brownish-green. The stems grow horizontally (procumbent). The leaves are round (orbicular), smooth wavy leaf margins (sinus), and arranged diffusely (spreading). Leaf cells are thin-walled without a triangular shape (trigones), at the edge of the leaf the cells are rectangular, the center is polygonal, and the basal cell is elongated, the oil bodies are scattered in the form of granules in the leaf cells. No ventral leaf (underleaves). The rhizoid is red-violet. *Jungermannia* sp. including dioecious plants. The capsules are ovoid brownish-black in color with relatively short cylindrical stalks (setas). The elaters are brown, the spores are yellowish. This species is found growing on a moist soil substrate.

## 17. Family Fossombroniaceae

The study found one species: *Fossombronia japonica*



FIGURE 18. Colonies of *Fossombronia japonica* in habitat.

Classification of *Fossombronia japonica* is :

Kingdom : Plantae  
Division : Marchantiophyta  
Class : Jungermanniopsida  
Order : Fossombroniales  
Family : Fossombroniaceae  
Genus : Fossombronia  
Species : *Fossombronia japonica*

This species is about 1-3 mm wide and about 2-10 mm long. The stems creep over the substrate. The leaves are yellowish-green, very dense and overlapping, arranged in a slightly spread (patent) to slightly upright (sub-erect). Leaf shape quadrat bilobed to broadly oblong-lingulate, leaf tips rounded, with slightly wavy margins (undulate), and irregular teeth (irregularly dentate). Oil bodies in leaf cells are small, numerous, and round to oval (ellipsoidal). The roots are not too much reddish to dark purple. This species includes monocious plants. The capsules are round, dark brown in color when ripe. *Fossombronia japonica* grows on a moist soil substrate with sufficient water.

## CONCLUSION

The moss plants found in the Nglanggeran Ancient Volcano Area are 23 species of moss. From those species, there are 2 species of Marchantiopsida, 2 species of Jungermanniopsida, 1 species of Anthocerotopsida, and 18 species of Bryopsida. In addition, there were 9 types of mosses identified up to the genus level and 14 types of mosses identified up to the species level.

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# Biodegradable Thin Layer from Tofu Liquid Waste by the Addition of Chitosan, Diammonium Hydrogen Phosphate, and Dipotassium Hydrogen Phosphate

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**Abstract.** In the past couple of decades, plastic pollution has risen to be the third-largest solid waste volume in the final garbage dump and has become a worldwide concern. The biodegradable polymer has been considered an alternative to the environmental problem from agricultural production due to the ability to degrade faster than synthetic plastic. However, the impacts on the ecosystem and the degradation time of the biodegradable plastic remain unclear. A novel decomposable biofilm material derived from the bacterial cellulose-chitosan film is being developed. Bacterial cellulose is a sort of organic molecule made by specific categories of bacteria. Most bacteria synthesize extracellular polysaccharides in natural habitats, such as cellulose, forming protective envelopes surrounding the cells. In the presence of microorganisms in the soil, this polymer in plastic degrades into CO<sub>2</sub> and H<sub>2</sub>O. Advantageously, plants would use the CO<sub>2</sub> used in photosynthesis while the water would dissolve in the soil pores so that easily spoil material would be harmless in the environment. The bacterial cellulose was constructed via a static culture of *Acetobacter xylinum*, while chitosan was introduced via a soaking method. The bacterial cellulose layer was incorporated with chitosan at different concentrations (0.5; 1.0; 1.5% w/v). The natures and behaviors of the bacterial cellulose-chitosan film were analyzed for the biodegradation test. The result portrayed that incorporating the bacterial cellulose film with chitosan provides a suitable time for seeding to seedlings. In conclusion, the material was attained and denoted wide potential applications for the agricultural field.

## INTRODUCTION

Plastic pollution has been a concern worldwide. After China with about 28% of the global amount, Indonesia placed the second most significant proportion by generating about 10%, both the Philippines and Vietnam yield 6% of the mismanaged plastic waste [1]. The high consumption of packages has entailed a large waste production. In plant seedlings, polyethylene plastics have traditionally been used, either dumped into the soil or burned after transplantation due to the vast volume of organic reagent added to cause it hardly recycled. Over and above that, when a seedling is removed from the transplant bag, root damage compromises the plant's development. It was hypothesized that putrescible containers are better for seedling maturation and are more environmental-friendly than the widely used polyethylene bags.

Biodegradable plastic has been considered to be an alternative to an environmental problem in the last few years. It can degrade faster than artificial polymers. Carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O) are generated in the

soil as a combination of microorganisms [2]. Beneficially, CO<sub>2</sub> would be utilized in photosynthesis, while the water would dissolve in the soil pores so that the decomposable material would be harmless in the environment.

Cellulose is the principal component of a compostable polymer. The sources of cellulose are primarily from plants such as wood and agricultural waste [3]. Biodegradable polymer manufactured from hydrocolloids such as *nata de coco* and *nata de soya* has a high polarity and is hydrophilic, providing high water vapor absorptivity and low oxygen permeability. This is due to hydrogen bonds in the molecular structure [4]. It is considered fragile and brittle during thermo-formation, leading to low-grade mechanical features regarding process-ability and ultimate use, limiting its scope for different packaging innovations [5].

Alongside plant-derived cellulose, various strain of acetic acid-producing bacteria can also generate cellulose, including the genera of *Acetobacter*, *Gluconobacter*, *Gluconoacetobacter*, and *Komagateibacter* [6]. On the basis of its capability to afford relatively huge quantities of polymers from a comprehensive variety of carbon and nitrogen resources, *Acetobacter xylinum* has been extensively employed as a model for basic and applied cellulose research [7]. *A. xylinum* needs an amount of sugar in the fermentation process in sucrose, sorbitol, glucose, and fructose. These bacteria are secreted outside of the cells in basic nanofibers, creating microfibrils and ribbons by extremely normal intra- and inter-molecular hydrogen bonds [8]. *Acetobacter xylinum*-produced cellulose has distinct physical properties from plant cellulose, such as finer microfibrils, tensile strength and crystallinity, and higher water purity and absorption capacity [9].

Bacterial cellulose can be combined with plasticizers or other biopolymers to improve its properties and expand its possible accomplishment in various fields [10]. Plasticizers must create a more elastic, versatile, and water-resistant polymer [11]. Glycerol is a plasticizer commonly used in manufacturing perishable plastics [4]. Therefore, attaching lipids like fatty acids bearing low polarity is essential to downscale the water vapor. *Nata de soya* is a high-cellulose food product from the liquid waste of tofu production (soya whey) with outstanding minerals like K, Cl, S, Ca, Na, Mg, etc., that play an essential role as enzymatic cofactors in the production of these polysaccharides [12]. K<sub>2</sub>HPO<sub>4</sub> (dipotassium hydrogen phosphate) that supplies potassium, (NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub> (diammonium hydrogen phosphate/DAP) provides nitrogen as a nutrient that arranges cell components, CH<sub>3</sub>COOH and chitosan played a role as an antimicrobial agent. The pH was adjusted to be four as an ideal condition for bacterial incubation. Besides, the optimum temperature for the fermentation process was between 25-35°C and placed in a room not exposed to direct sunlight.

Chitosan is a naturally occurring unbranched homopolymer earned from chitin, which is a vast by-product of seafood cultivation. Chitosan is harvested via removal of acetyl group COCH<sub>3</sub> using alkali or deacetylation reaction. Further explained by Goy, Morais, and Assis that chitosan and its derivative *N,N,N*-trimethylchitosan (TMC), that can dissolve in water, showed antimicrobial activity against Gram-positive and Gram-negative bacterium strains [13]. The antimicrobial activity has been mainly attributed to its major amino groups, which may interact electrostatically with anionic cell wall components. The electrostatic interaction between positively charged R-N(CH<sub>3</sub>)<sub>3</sub><sup>+</sup> sites and negatively charged microbial cell membranes has been underlined as the antimicrobial mechanism of action [14].

In the present study, bacterial cellulose-chitosan was tested. Hence, it is a very eco-friendly method for seedling by using decayable plastics. The biodegradability test was conducted on the polymer sample for finding the best chitosan concentration with a suitable degradation time for the seedling.

## MATERIALS AND METHODS

### Materials

The fundamental material to manufacture the bacterial cellulose was liquid waste from tofu production collected from the home industry of tofu located in Polosiyo, Srandakan, Bantul. Yeast and sucrose were purchased from the commercially available. While, (NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub>, K<sub>2</sub>HPO<sub>4</sub>, acetic acid, and chitosan were purchased from Sigma-Aldrich.

### Production of bacterial cellulose (BC)

Bacterial cellulose (BC) was fabricated from a static culture of an *A. xylinum* strain provided as the stock solution. Verschuren *et al.* developed a method for preparing the medium, which was adjusted [14]. A total volume of 400 mL of the liquid waste of tofu production was heated and maintained with 20 grams of sucrose, 1 gram of (NH<sub>4</sub>)<sub>2</sub>HPO<sub>4</sub>, and 1 gram of K<sub>2</sub>HPO<sub>4</sub>. Acetic acid was used to modify the pH of the medium to 4.5. Thereafter, 80 mL of *A. xylinum* was added to the pH-adjusted liquid waste water-based medium and poured into moulds for fermentation. The fermentation was performed under decontaminated stationary state at 30°C for seven days to form the BC.

## Preparation of chitosan solution

In this research work, chitosan was deployed as an antimicrobial agent. The chitosan-based coating with acetic acid was created by considering and adjusting the procedure given by Xing *et al.* [16]. The chitosan powder was weighed and dissolved in 50 mL of 2% acetic acid solution in water to obtain different concentrations at 0.5; 1.0; and 1.5% w/v. A magnetic stirrer was used to mix the mixture at 500 rpm for 1 hour until a uniform chitosan solution was obtained.

## Preparation of bacterial cellulose-chitosan films

After the BC was harvested, it was cleansed repeatedly with plenty of tap water until a neutral pH was acquired. Then, the BC was boiled in 200 mL of purified water for 30 minutes to eliminate all the cells stuck within the pellicle membrane. Afterwards, the bacterial cellulose was squeezed and rinsed multiple times with distilled water before being soaked in distilled water until the pH of the water became neutral. The BC was then immersed for 6 hours in the chitosan solutions formulated at varied concentrations (0.5; 1.0; and 1.5% w/v). After that, the bacterial cellulose was taken out from the solutions. Then, it was air-dried at  $27\pm 1^\circ\text{C}$  (natural drying process) for 6 hours and dehydrated in the oven at  $40^\circ\text{C}$  for 1 hour. The moistureless bacterial cellulose-chitosan film was loaded up in a plastic bag for henceforward scrutiny.

## Biodegradation test

The bioplastics were cut into  $3 \times 2.5$  cm. The initial weight of the film was recorded. Then, the bioplastics were buried into the ground at 8 cm depth for 7 days. After that, the bioplastics were extracted from the soil and weighed and measured using analytical balance and ruler, respectively. Any mechanical characteristics changes caused by the degradation process were found. The following formula measured biodegradability.

$$\text{Microbial resistance (\%)} = \frac{\text{Final mass} - \text{Initial mass}}{\text{Initial Mass}} \times 100\%$$

## RESULTS AND DISCUSSIONS

### Bacterial cellulose (BC) from the liquid waste of tofu production

A white transparent sheet of *nata de soya* is 30 cm in length, 23 cm in width, and 0.5 cm thick can be established after 7 days of the fermentation process (Fig. 1).



**FIGURE 1.** The bacterial cellulose film initiated by *Acetobacter xylinum* incubated at  $30^\circ\text{C}$  for 7 days

The most common carbon sources in *nata* synthesis are glucose, sucrose and fructose. The production of *nata* has been considerably influenced by major and minor nutrients.

## Bacterial cellulose-chitosan film

The chitosan coating inhibited the growth of bacteria, yeast, and moulds, as chitosan possessed excellent antimicrobial activity [17-19]. This antimicrobial helps the thin film bacterial cellulose have a longer time to be degraded as a seedling bag. Not only act as an antimicrobial, but chitosan could also improve the mechanical properties of bacterial cellulose.

The potency of chitosan as an antimicrobial agent has been revealed since a long time ago [20]. Chitosan has a vigorous antimicrobial activity against Gram-positive and Gram-negative bacteria [21, 22].

### Biodegradation analysis

Before further evaluation, the dried BC-chitosan film (Fig. 2) must be stored in a sealed plastic bag to avoid moisture exposure. Residual stress and humidity levels have a substantial influence on the tensile properties of compressed BC-films. Longer heating times escalate the tensile strength (TS) and tensile modulus (TM), especially under lower humidity conditions. Due to a tighter network structure of the nanofiber and higher compressive residual stress, this increase translates to reduced cellulose chain mobility. Internal tensile stress resists external tensile stress, causing the TS and TM to increase. Increased humidity, on the other hand, caused lattice planes to relax, lowering compressive residual stress. As an outcome, TS and TM lessened, and the film's inflexibility lowered. [23].

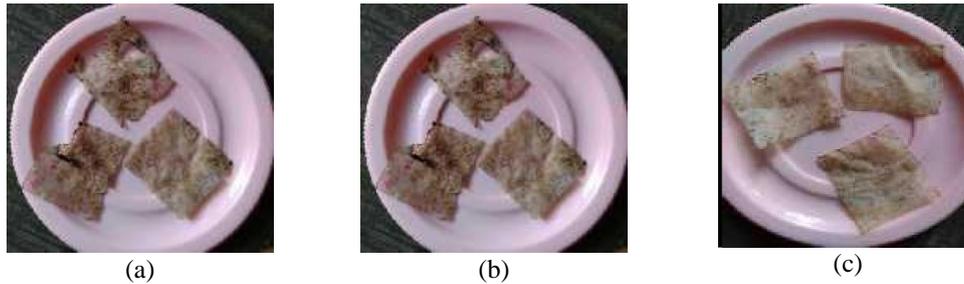


**FIGURE 2.** The dried bacterial cellulose-chitosan film

The biodegradability of polymer was tested to see how rapidly microorganism would break it down if it released into the environment. On top of that, it also aims to evaluate the degree of environmental deterioration of biodegradable plastics to measure an environmentally safe material. The soil burial test was used to measure the biodegradability of bioplastic. The plastics were buried in the ground as many soil microorganisms could support the process of plastic degradation [24, 25]. In Table 1, the degradation can be observed by reducing the mass of the respective specimens buried in the ground. Soil moisture is very influential on the degradation process as it will facilitate microbes to consume plastic as a food source. Other considerations include pH, temperature, carbon/nitrogen sources, the prevalence of pollutants, and the supply of nutrients [27].

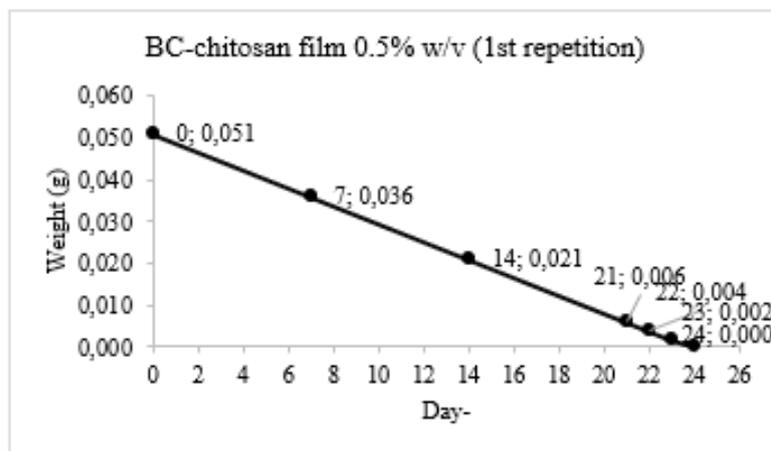
**TABLE 1.** The biodegradation test of the BC-chitosan film for 7 days

Concentration of chitosan (g/100ml)	Repetitions	Initial mass (g) Day-1	Final mass (g) Day-7	Degradation (g) Day-7	Microbial resistance (%)	Average microbial resistance (%)
0.50	1	0.051	0.036	0.015	0.29	0.30
	2	0.059	0.041	0.018	0.31	
	3	0.058	0.041	0.017	0.29	
1.00	1	0.046	0.033	0.013	0.28	0.26
	2	0.044	0.034	0.010	0.23	
	3	0.043	0.032	0.011	0.26	
1.50	1	0.037	0.028	0.009	0.24	0.24
	2	0.044	0.033	0.011	0.25	
	3	0.043	0.033	0.010	0.23	



**FIGURE 3.** The physical appearance of BC-chitosan films during the biodegradation test (a) 0.5; (b)1.0; (c)1.5% w/v.

Figure 3 visualized the physical features of BC-chitosan films during the biodegradation investigation. The alterations could be seen since day one of the tests, indicating that the biodegradation of the BC-chitosan films had begun. The film's physical alterations, particularly in terms of size and shape, shrank as the film's compactness deteriorated over time, eventually causing the film to lose out on its original form and dimension [27, 28]. It shows the results of biodegradation from composting tests for bacterial cellulose. It is clear from figure 3 that in the case of biodegradation tests from composting, the BC-chitosan films lost over 22.73; 25.00; and 30.51% of their weight after seven days. Moreover, a percentage of weight loss boosted over time for BC-chitosan films of 0.5; 1.0; 1.5% w/v, consecutively.



**FIGURE 4.** The predicted weight-loss of BC-chitosan films during the biodegradation test.

Figure 4 depicts the predicted weight-loss of 1<sup>st</sup> replication of BC film with chitosan concentration of 0.5% w/v during the biodegradation test. The weight of BC film decreased from 0.051 g on day 1 to be 0.036 g on day 7. The weight was predicted to fall to 0.021 g and 0.006 on day-14 and -21, successively. Interestingly, the BC-chitosan films were fully degraded on day-24 of the experiment. The changes in the physical properties of the bacterial cellulose resulted from the biodegradation process that occurs in the soil [29]. The microbial cluster within the soil transforms the existing digestible parts into carbon dioxide, methane, water, and biomass when bacterial cellulose film is immediately shaped [28]. This result indicates that plant seedlings, such as chilli, spinach, etc., will be readily transplanted in the 3-4 weeks.

An advanced study is needed to identify the responsible microorganisms that degrade bacterial cellulose. The *Bacillus* sp. was previously reported to have the most noticeable cellulase activity, whereby cellulase is the enzyme I charge of the cellulose breakdown [30-32]. The cellulase erodes the cellulose in three ways; (i) the 1,4- $\beta$ -endoglucanases randomly cleave the internal chains of cellulose and inventing new ends of shorter chains, (ii) the 1,4- $\beta$ -exoglucanases attack non-reducing or reducing ends of cellulose and merging the fibrils from crystalline cellulose, (iii)  $\beta$ -1,4-4-glucosidase hydrolase cellobiose and water-soluble cellodextrin into glucose [33]. On the other hand, *Rhizopus* sp., predominantly settled in the soil, was discovered to have the propensity to cultivate cellulase, accountable for cellulose breakdown [34]. Additionally, Ghosh and Ray highlighted that cellulase might be achieved hastily and commercially using extracellular endoglucanase originated by *Rhizopus oryzae* from liquid-state fermentation (LSF) and solid-state fermentation (SSF) of various agricultural wastes. In addition, it also discovered that the endoglucanase synthesized could readily and rapidly convert cellulosic wastes into glucose without alkali or acid pre-treatments [35].

## CONCLUSIONS

Chitosan was successfully incorporated with bacterial cellulose film to invent an environmentally friendly liable to rot polymer. The biodegradable quality of the bacterial cellulose-chitosan was evaluated and showed a good result, even though the addition of chitosan does not represent a considerable percentage. On day 24 after the burial, the bacterial cellulose-chitosan had entirely degraded. Finally, bacterial cellulose has been shown to promise as a seedling bag substitute for reducing environmental pollution. The functionality of bacterial cellulose might be improved by adding additive ingredients, such as an antibacterial agent, which brings up new possibilities for different industrial uses. The biodegradable film is an alternative-producing seedling container since it can then be transplanted directly into the soil without removing the bag, thus reducing the risk of root damage at the time of transplantation.

## ACKNOWLEDGEMENTS

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# Development of Biology Practicum Guide Based On Android Application Using Adobe Flash Professional CS6 for Senior High School Level XI

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**Abstract.** The balance of affective, psychomotor, and cognitive in the learning process can be achieved through practicum. However, results of needs analysis in 4 schools in Yogyakarta showed that biology teachers were still using conventional practicum guides that have been made since long time ago without any revisions. Updating such guide is needed to facilitate the implementation of practicum and understanding the biology material. This study aimed to develop and determine the quality of the Android-based Biology practicum guide product made using Adobe Flash Professional CS6. This study was research and development with 5 steps, namely (1) identification of potential and problems, (2) data collection, (3) product design, (4) product validation, and (5) product improvement. Obtained data was analysed qualitatively to determine the eligibility of the product. The initial product was in the form of a 24 MB apk file consisting of an introductory menu, rules, introduction to laboratory equipment, practicum guides, bibliography, and profiles. Application products can be installed on Android OS smartphones at least version 5. Users also need to install Adobe Air as the product installer. This product was assessed by 4 validators, namely media experts, material experts, and 2 high school biology teachers in DIY with an average validation score of 3.7. The results of this score fall into the “very good” category and deserve to be tested after improvements based on validator comments and suggestions which include menu additions, language writing, image changes, transition animations, title design, and page switching consistency.

Keywords: research and development, android application, biology practicum guide, Senior High School

## INTRODUCTION

In the Regulation of the Minister of Education and Culture number 69 of 2013 concerning the Basic Framework for the Curriculum Structure of Senior High Schools/Madrasah Aliyah, it is stated that there are 2 challenges faced in the world of Indonesian education, namely internal and external challenges [1]. The internal challenge faced by Indonesia in the realm of education is how to strive so that the younger generation of Indonesia can become competent and skilled human resources at a productive age. In the external sphere, Indonesian education is challenged to produce human resources who are competitive not only on a national scale, but also on an international scale, especially in the current era of globalization. To answer these problems, the government made changes to the Indonesian education curriculum, namely from School-Based Curriculum to the 2013 curriculum [2].

One of the characteristics of the 2013 curriculum is developing a balance between spiritual and social attitudes, curiosity, creativity, cooperation with cognitive and psychomotor abilities as stated in the Regulation of the Minister of Education and Culture number 69 of 2013 [3]. This can be achieved through science-based learning that utilizes various learning resources. Likewise in biology learning where it is not only done theoretically from reading sources, but also based on the implementation of practicum [4].

Biology learning through practicum will make it easier for students to understand the material because it is practiced directly by and for students [5]. In addition, understanding the concepts and principles of science is easier

to understand through practicum activities. Students are also familiar with the activities of working scientifically through practicum activities. The main advantage of implementing practicum activities is that students can interact directly with the object of their research and it is easier to improve students' thinking skills [6].

Practicum activities cannot be separated from the practicum guide. The practicum guide is one type of student's worksheet that functions to assist and direct students in building knowledge and finding concepts [7]. Teachers and students use practicum guides as guidelines starting from preparation, implementation, data analysis and reporting of practicum activities so that practicum activities are in accordance with scientific procedures and minimize the occurrence of work accidents [8]. Practicum guides are usually prepared by the teacher concerned and the teaching staff who handle the practicum activities by following the rules of scientific writing.

The results of interviews with Biology teachers at SMA Negeri 1 Kalasan, SMA Negeri 8 Yogyakarta, SMA Bopkri 2 Yogyakarta, and SMA Santo Mikael Sleman showed that the practicum guide was made by subject teachers directly and in the form of a cookbook or like a recipe book. The teachers feel comfortable using a cookbook-based practicum guide because it makes the process of achieving biology learning goals easier and students' creativity is still explored because curiosity arises after carrying out practicum activities. In addition, the practicum guide used is still conventional, namely using student worksheet paper-based and some teachers still writing the practicum guide manually on the blackboard. The worksheets used are worksheets that have been made some time ago and have been used in various batches. This form of practicum guide is considered impractical because it requires a lot of paper to print it, causing piles of worksheets on the teacher's desk. Then, for teachers who write practicum guides manually on the blackboard, it takes more time to do it. Teachers also have a little difficulty in making learning media using technology. In addition, the teacher also thinks that this conventional practicum guide is less attractive and seems 'old school'. Another obstacle faced by teachers in making worksheets is the availability of time that is not possible in which a teacher must carry out the task of teaching, correcting and conducting practicum and other unexpected additional tasks.

One solution that can be developed to overcome these problems is to use a practicum guide in the form of an android application where teachers can enter practicum guide content in a more attractive form, such as using an attractive visual display. The soft file practicum guide has the advantage that it can be shared with students easily via social media and can attract students' interest to study practicum first before carrying out activities. The teacher simply acts as a facilitator so that there is no failure in practicum activities, while students can easily read the practicum guide anywhere through a smartphone device that uses the Android operating system. This is supported by the tendency of students who often carry smartphones. Therefore, smartphones can be used for learning so that learning activities run more smoothly and save time. Students do not have to worry about not being able to re-learn practicum activities because after collecting reports, students can still reread practicum activities through the android application-based practicum guide.

Research that is relevant to this research, namely "Development of Macromedia Flash-Based Biology Interactive Teaching Media on Human Digestive and Respiratory System Materials for Class XI SMA / MA" with output in the form of interactive teaching media for Macromedia flash-based digestive system materials [9]. Other research that is a reference source, namely the research "Development of a Virtual Laboratory Excretion System in Improving Learning Motivation of High School Students" with output in the form of a virtual lab [10], as well as research "Development of Adobe Flash-based Biology Learning Media to Improve Competence Mastery in 2013 curriculum" with output in the form of flash-based teaching media [11]. Therefore, to overcome the problems experienced by teachers and the opportunities for using android as a learning medium, the researchers developed an android-based practicum guide application

This study aims to develop a practicum guide application made using Adobe Flash Professional CS6 for Biology subjects for class XI SMA with a cookbook arrangement and to determine the quality and feasibility of the developed application product. This development is one solution that in the 2013 curriculum learning does not only come from one media, but can also be sourced from electronic media so that it can be easily learned and read anywhere and anytime so that student understanding is higher and teacher needs are also met. The novelty of this research is to present a Biology practicum guide for class XI SMA in an android application that is practically equipped with other materials, namely the display of laboratory rules and the introduction of Biology laboratory equipment to help students introduce biology laboratory tools.

## METHODS

This research is a type of research and development or Research and Development (R&D). The research was carried out to develop new products in accordance with needs analysis [12]. The research procedure carried out by the researcher refers to the guidelines for the R&D research steps according to Borg and Gall in Sugiyono [13] with modifications. The stages of R&D research consist of 10 stages. In the research on developing an android application practicum guide in Biology lessons for class XI SMA, the researchers only carried out stages 1 to 5 due to time constraints and several other factors, such as research restrictions which only reached the initial development stage and the first product's revision. Researchers are striving for this research can be continued for stages 6-10. The following are the research procedures that were carried out in this study: (1) Identification of Potential and Problems. This stage was done through observation and interviews of biology teachers to identify the problems that are currently occurring in biology learning and the potential that can be developed to overcome the problems. (2) Need Analysis. In this study, the need analysis process was carried out by analysing data of interview results to determine school needs and literature studies to find relevant research and reference sources in the preparation of this product component. (3) Developing Product Design. In product design there are several steps taken, including determining the material to be made a practicum guide, formulating the objectives and practicum steps, designing the background, making applications, and making credits and bibliography. (4) Product Validation. Validation is carried out to assess the quality of the product design developed. The validation carried out in this study is a validation of rational thinking and expert knowledge. (5) Design revision. The evaluation results from the teacher become revision material for the product design that is developed. Researchers have revised the product design according to what the experts judge [13].

There are two types of data obtained by researchers, namely qualitative data and quantitative data. Qualitative data obtained from the results of need assessment interviews and suggestions from experts when validating the product. The results of the interviews were analysed by researchers to write an analysis of school needs, while the product validation comments were criticisms and suggestions about the products that the researchers had developed. Quantitative data obtained from the assessment of experts when validating the product. The total score obtained from the validator's assessment will be averaged, then adjusted to the scale range that has been calculated by the formula [14].

$$\text{Scale Range (RS)} = (m-n)/b$$

where m = highest score, n = lowest score, b = number of classes.

The calculation of the scale range becomes the Scale Range (RS) = (4-1)/4 so that RS = 0.75 is obtained. The average score obtained in the validation results is then converted into qualitative values based on the following table [14].

**TABLE 1.** Guidelines for Conversion of Calculation Scores to Qualitative Values

Score Interval	Category
$3,25 < x < 4$	Very good
$2,50 < x < 3,25$	Good
$1,75 < x < 2,50$	Poor
$1 \leq x < 1,75$	Very poor

## RESULTS AND DISCUSSION

This research begins with conducting interviews to explore the potential and problems from the results of the needs analysis at 4 schools in DIY. Interviews were conducted with biology teachers in class XI from SMA N 1 Kalasan, SMA N 8 Yogyakarta, SMA Bopkri 2 Yogyakarta, and SMA Santo Mikael Sleman. Based on the interview, some teachers stated that they had used IT-based media to help carry out practicum activities, but it was not optimal, while some other teachers stated that they had never used IT media in the implementation of practicum in class. In this era of globalization, based on personal experience it is undeniable that students and us as humans cannot be separated from the existence of android. Therefore, the researcher offers a solution so that the implementation of the practicum

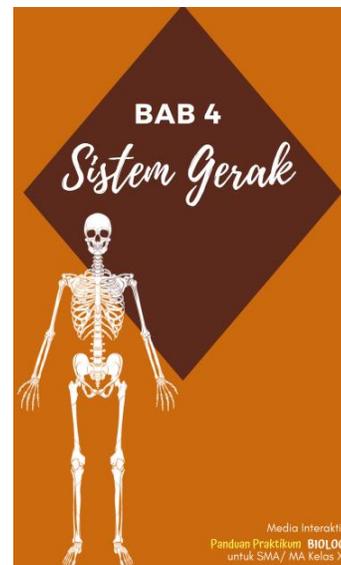
becomes more interesting and students can be enthusiastic in carrying out practicum activities by presenting a practicum guide in an application. With the application-based practicum guide is expected to facilitate the implementation of practicum activities. Researchers also hope that through this application students become more enthusiastic about learning to understand concepts in Biology lessons. It is said that multimedia-based learning media presented in the form of interactive documents can create learning that is fun, interesting, and easy to understand [15]. The teachers who were interviewed were enthusiastic and interested in the development of the application media for the Biology practicum guide for class XI SMA.

Based on the need analysis mentioned above, the developing product design was carried out through the process consisted of several stages, namely (1) determining the subject matter and compiling learning tools; (2) determine the components and create the background for the application; (3) compiling a practicum guide; (4) create story boards and android application prototypes for biology practicum guides; (5) making practicum guide android applications using Adobe Flash Professional CS6; and (6) initial product installation.

The basic material in the biology practicum guide for class XI SMA is adapted to the KD biology subject for class XI in Appendix Number 7 of the Minister of Education and Culture Number 24 of 2016 concerning KI and KD Lessons in the 2013 Curriculum. which amounted to 14 KD and distributed for odd and even semester material [3]. The reason the researcher developed a practicum guide from 14 KD is to make it easier for teachers and students to carry out learning because in one application it covers all practicum activities in 2 semesters at once. The subject matter is also used as the basis for making learning tools, including syllabus and lesson plans which function as learning scenarios when the android application media for this biology practicum guide is used in the classroom. There are 2 methods used in learning, namely practicum and discussion. Some examples of designs in these applications can be seen in the following image.



**FIGURE 1.** The cover design of the practicum guide application for of Biology Class Level XI



**FIGURE 2.** One example of the background design of the Chapter 4 practicum guide

The background is also used in making practicum guides. The practicum guide is made in accordance with the LKPD variables where the practicum guide application product is developed by adjusting the learning objectives and materials of each relevant KD [16]. In addition, the assignments and exercises in the practicum guide are also adjusted to the learning objectives, and the presentation of the practicum guide is clear and easy to read by users.

Each part that has been designed is combined into a prototype according to the story board. The story board contains scenarios of how to use, transitions, and explanations of each part in the application. The prototype was created using Microsoft Power Point 2019 software. The prototype will be used as a guide in making an android application for biology practicum guides for student level XI using Adobe Flash Professional CS6 software. In this stage the researcher collaborates with A.N.R. as an application developer.

The Biology practicum guide application in this study was developed using Adobe Flash Professional CS6 software. Adobe Flash Professional CS6 is the latest version of the previous software development, namely Adobe Flash Professional CS3, Adobe Flash Professional CS4, and Adobe Flash Professional CS5 [17]. Flash is software that is used to create animations, presentation media, applications, games, web building, and even learning media [18]. In developing media, users can use templates or create new views using the workspace. The workspace consists of a menu bar, panel, timeline, stage, and toolbox [19]. The advantage of flash animation is that it is very suitable for use as internet-based application content because it uses vector graphics so that it is small in size [20]. Flash documents that have been created will be saved with the extension .fla (FLA). This flash document can also be published by using the File > Publish command which will automatically generate a compressed file with the .swf (SWF) extension. However, the file extension for android apps is .apk (android package). To produce android applications, application developers use the "AIR for Android Setting" feature when they want to start creating projects [21].

Android is an operating system intended for mobile based on Linux. Initially developed by Android Inc until 2005 it was acquired by Google Inc [22]. The first release of android was in 2007 and at the same time Google also released android codes under the Apache license, which is a software license and an open standard for mobile [23]. Android being a provider of an open platform (open source) for anyone who develops their own application is very interesting to many companies in related fields. Companies can develop their own devices that are tailored to market needs and use Android as their operating system [24]. Therefore, anyone including teachers can freely and creatively develop learning devices in the form of android applications. In addition, since its initial release, Android has developed from version 1.0 to version 10.0 [25].

The initial product developed produces an apk file of 24 MB which can be shared via cloud storage, sending documents via chat or email. The apk file can be installed on a smartphone based on Android at least version 5 or Lollipop. Before installing the practicum guide application, users need to activate the Unknown Sources feature on Android. This activation aims to allow Android to install applications that are not from the Google Play Store. The feature is found in the settings menu, then select security and enable the Unknown Sources section. Next, users need to install Adobe Air as the operator of the practicum application. The Adobe Air application can be downloaded for free through the Playstore.

This initial product is designed to be a practicum application that can make it easier for teachers and students to learn. Therefore, this application is equipped with supporting components, such as student and teacher rules so that both parties always read and obey these rules while carrying out activities in the laboratory. In addition, there is also an introduction to laboratory equipment which contains photos of biological laboratory equipment used in practicum activities in the application. The photo is expected to help students get to know the laboratory equipment that will be used. In addition, the bibliography section can also be a reference for users to add reading material to biology material. The existence of these supporting components is intended so that this media can increase the effectiveness of learning [15]. The operation of this application is also facilitated by the presence of transition buttons, such as the home button to return to the home menu, the back button, and the round button. Move each page can use the touch command to continue the page and swipe to return to the previous page.

The application product of the biology practicum guide is then validated to assess the quality of the product that has been developed. Product validation was carried out by 4 validators, namely Class XI High School Biology teachers, material experts, and media experts. Each validator performs 1 time product validation in accordance with the assessment questionnaire given by the researcher. The category for calculating the score is calculated based on the scale range formula such as the method section. The validation by the Biology teacher of class XI SMA was carried out by D.E.W (validator 1) from SMA N 1 Banguntapan and F.G.P. (validator 2) from SMA Santo Mikael Sleman. Material validation of this practicum guide application product was carried out by I.Y.L (validator 3), while media validation was carried out by H.M.A. (validator 4). The scores obtained from the assessment results of class XI high school Biology teachers, material experts, and media experts were recapitulated and averaged. The average results are compared with the score category table. The following is a recapitulation table of product validation results.

**TABLE 2.** Initial product validation results

<b>Validator</b>	<b>Score Mean</b>	<b>Criteria</b>
Validator 1	3,6	Very good
Validator 2	3,9	Very good
Validator 3	3,6	Very good
Validator 4	3,6	Very good
<b>Overall average</b>	<b>3,7</b>	<b>Very good</b>

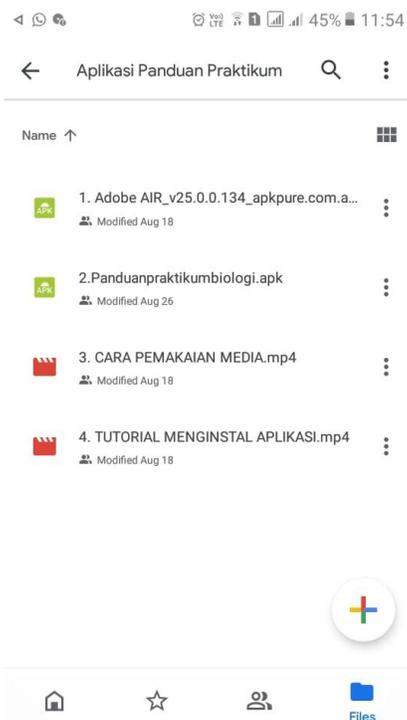
Based on these calculations, it is known that the average score of the Biology practicum guide application product is 3.7 and is included in the very good criteria. The four validators also argue that the product developed is worth testing with some improvements. In addition to providing an assessment score, the four validators also provided some comments and suggestions namely the completeness of the practicum material, fixed the consistency of the practicum material, added HOTS's questions, adding the reference sources, fixed the writing, completing the menu's, and fixed the display cover for the improvement of this application product. These comments and suggestions are used as the basis for product improvement so that the quality of this product is getting better.

There are several aspects that need to be improved, namely the completeness of the practicum material, the consistency of the practicum material, the depth of the practicum material, the reference source, the writing of the language, the completeness of the components, and the display of the media. Improvements in the aspect of completeness of practicum material are carried out by adding practicum activities in chapter 7, from 2 activities to 4 practicum activities. The validator is of the opinion that it is important to include the activity of calculating human lung capacity and respiratory rate of animals and plants in chapter 7. The consistency of the practicum material is improved by equating the introductory image with the object of the study so that the material remains consistent. To deepen the practicum material, the researcher added HOTS-level discussion questions based on suggestions from the validator. In addition, the researcher also added questions after the introductory part in each practicum activity. It aims to stimulate students' curiosity when they want to do practicum activities. In the reference section there is a change of introductory illustration photos sourced from scientific sources. In addition, there are several improvements to the transition animation, namely the improvement of the hyperlinks of each button, the activation of some previously disabled buttons, as well as improvements to touch and swipe navigation. In the final product, touch navigation is only used to press buttons, while swipe commands can be used to move pages in two directions or back and forth. The researcher also corrected some language writing errors in the initial product. There are 2 new menus added by the researcher to complete the application component of this biology practicum guide, namely the tutorial menu for using the application and the report making guide. Researchers also add reading references to the bibliography to help users. In addition, each reference in the bibliography when pressed will be connected directly to the article in the bibliography. The aspect that received many comments and suggestions from the validator was the media display where there were several changes to the position of the application cover, improvement in color selection, improvement in the design of the title of the practicum guide, and improvement of the introductory illustration image.

The final result of this practicum guide application product is distributed to teachers and students in the form of a Google Drive link. The link contains the Adobe Air apk file, the Class XI Biology Practicum Guide apk file, video tutorials on how to install the two applications, and application operation tutorial videos as shown below. After the two applications are installed, the display of the Adobe Air application icon and the Class XI Biology Practicum Guide application will appear as shown in the following image.

There are several things that become the limitations of this developed product, namely this product was developed based on the results of interviews with 4 Biology teachers in public and private schools in the Special Region of Yogyakarta so that the information obtained is quite limited. Therefore, the product developed is only relevant to the problems of teachers in the 4 schools and not necessarily relevant to other school conditions. In addition, to operate this practicum application, users need the Adobe Air (Adobe Integrated Runtime) application. Because Adobe Air is used to run flash-based programs, users must install this application before installing the practicum guide application. The Adobe Air apk file has also been included on the google drive link shared by the researcher. Basically, to install these two applications does not require such a large storage space compared to installing applications from the Play Store. Adobe Air application storage can be transferred to the SD Card so it does not interfere with the user's Android internal storage.

This practicum guide application product is also not equipped with facilities to answer discussion questions. This is because the product developer software is not yet compatible to develop this facility. Therefore, when carrying out practicum activities using this application guide product, students need to write answers to conventional discussion questions. In addition, to develop this application requires a higher cost than conventional practicum guides, but its use can be applied for a long period of time. If you look at the duration of use and the costs incurred, it is possible for teachers to develop similar products by collaborating with Biology teachers from other schools.



**FIGURE 3.** Contain in the google drive link that is shared with students and teachers



**FIGURE 4.** The practicum guide application icon and adobe air will appear after installation

## CONCLUSION

Based on research and development of android application media for Biology practicum guides for SMA/MA level XI using Adobe Flash Professional CS6, it can be concluded that:

1. Development of a product design application for Biology practicum guides for SMA/MA level XI using Adobe Flash Professional CS6 produces a 24 MB apk file that can be installed on smartphones with a minimum Android OS version 5. Users need to install Adobe Air as the installer for the practicum guide application. The components of this application consist of an introductory menu, rules, introduction to laboratory equipment, practicum guides, bibliography, and profiles.
2. The application media for the Biology practicum guide for SMA/MA level XI has a product quality with a "very good" category based on the assessment of 4 validators. The recapitulation of the validation results from 4 validators has an average score of 3.7.
3. Based on the validator's assessment, the application product of Biology practicum guide for SMA/MA level XI is feasible to be tested in a limited scope. However, the validator states that this can be done if the researcher makes improvements to the comments and suggestions from the validator.

As a recommendation for better future research, it is better to conduct a needs assessment interview with more than four Biology teachers in class XI SMA in order to get a wider data coverage. In addition, the development of practicum guide applications can use more compatible software to create programs that can provide facilities for filling out answers to the results of practic activities directly; and no need to use other software to run the application product so that users do not need to install 2 applications.

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# Application of Fuzzy C-Means to Detect Students' Mathematical Connection Ability at Anak Pelangi Homeschooling

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**Abstract.** Mathematical connection is the ability to relate mathematical concepts to both the mathematical concepts themselves and link mathematical concepts to other fields. The application of data mining can help analyze data obtained from the condition of students' mathematical connection abilities in order to determine study groups. The data mining technique used is to use the clustering technique. One of the clustering methods is the Fuzzy C-Means algorithm which has high accuracy and fast computation time. Test the validity of the clustering results to detect the ability of mathematical connections using partition coefficient calculations obtained results of 0.830, so it can be said that the results of clustering belong to the good category. From the results of data analysis of 20 class VII students at Anak Pelangi Homeschooling, it was found that 9 students (45%) had good mathematical connection skills, so that 9 students were included in the superior study group and 11 students (55%) in the regular study group.

## INTRODUCTION

Education is a form of conscious effort that aims to prepare the subject of education in the face of an environment that continues to change. From this education, it is expected that students will be able to respond to society. One of the goals of education is to produce graduates who master the branches of science or technology to meet the national interest and increase the nation's competitiveness.<sup>1</sup>

Mathematics is also called the queen of science because mathematics is the source of other sciences. There are many branches of science whose theory development is based on the development of mathematical concepts. For example, many theories and branches of physics and chemistry were discovered and developed through the concept of calculus, especially differential equations. Another example is the economic theory of supply and demand which was developed through functions and calculus of differentials and integrals.<sup>2</sup> NCTM classifies basic mathematical abilities into five ability standards, namely mathematical understanding, mathematical problem solving, mathematical reasoning, mathematical connections, and mathematical communication.<sup>3</sup>

Mathematical connection ability is one of the standard process components in the Principles and Standards for School Mathematics, in addition to problem-solving, representation, reasoning, and mathematical communication skills. Mathematical connection is the ability to relate mathematical concepts both between mathematical concepts themselves and relate mathematical concepts to other fields, including connections between mathematical topics, connections with other disciplines, and connections with everyday life. Mathematical connection skills are needed to connect mathematical ideas in order to find solutions to mathematical problems inside and outside school.<sup>4</sup> If students have good mathematical connection skills, then students' understanding of mathematics will be deep and last for a long time.<sup>5</sup>

The application of data mining can help analyse the data obtained to classify mathematical connection abilities as in the research conducted by Mofleh Al-Diabat entitled Fuzzy Data Mining for Autism Classification of Children.<sup>6</sup> The data mining technique used is the clustering technique. Clustering techniques are used in data mining to group objects that have similarities in the same class.<sup>7,8</sup> One of the clustering methods is using the fuzzy clustering method, namely the Fuzzy C-Means algorithm. Fuzzy C-Means has a high level of accuracy and fast computation time.<sup>9,10</sup> Fuzzy C-Means clustering is a method derived from fuzzy logic, which is suitable for solving multiclass and ambiguous clustering problems.<sup>11</sup> Many studies use Fuzzy C-Means to classify data, such as Edy Rahman's research entitled Application of Fuzzy C-Means Algorithm for Determine Field of Interest in Information System Study STTH Medan and research conducted Samarjit Das, which uses Fuzzy C-Means for vehicle pollution clustering.<sup>12,13</sup>

Knowing the basic abilities of Anak Pelangi Homeschooling's students can be used as input in determining study groups or learning strategies to be used. Mathematical connections can be indicated in three aspects: connections between mathematical topics, connections with other disciplines, and connections with students' real-world connections with everyday life.

## LITERATURE REVIEW

### Fuzzy C-Means

Fuzzy clustering is part of pattern recognition. Fuzzy clustering plays the most important role in the search for structures in the data.<sup>14</sup> Fuzzy clustering is a technique to determine the optimal cluster in a vector space based on the Euclidian normal form for the distance between vectors.<sup>15</sup> Fuzzy C-Means is a data clustering technique in which the existence of each data point in a cluster is determined by the degree of membership.<sup>16</sup> Fuzzy clustering is more natural than hard clustering. Data that lies within the boundaries of several classes are not forced to be part of one of these classes, but the data is represented using membership degrees.<sup>17</sup>

The basic concept of Fuzzy C-Means first is to determine the center of the cluster, which will mark the average location for each cluster. In the initial conditions, the center of this cluster is still not accurate. Therefore, each data point has a degree of membership for each cluster. The Fuzzy C-Means algorithm is as follows.<sup>18</sup>

1. Input data to be in cluster X, in the form of a matrix measuring  $n \times m$  where  $n$  is the number of data samples,  $m$  is each data attribute.  $X_{ij}$  represents the  $i$ -th sample data ( $i = 1, 2, \dots, n$ ) and the  $j$ -th attribute ( $j = 1, 2, \dots, m$ ).
2. Define the following elements:
  - a) Number of clusters =  $c$
  - b) Rank =  $w$
  - c) Maximum iteration =  $MaxIter$
  - d) Smallest expected error =  $\xi$
  - e) Objective function  $P_0 = 0$
  - f) Initial iteration  $t = 1$
3. Generate random numbers  $\mu_{ik}, i = 1, 2, \dots, n; k = 1, 2, \dots, c$  as elements of the initial partition matrix  $U$ . Count the sum of each column:

$$Q_i = \sum_{k=1}^c \mu_{ik} \quad (1)$$

with  $j = 1, 2, \dots, n$ . Count

$$\mu_{ik} = \frac{\mu_{ik}}{Q_i} \quad (2)$$

4. Calculate the center of the  $k$ -th cluster expressed by  $V_{kj}$  with  $k = 1, 2, \dots, c$  and  $j = 1, 2, \dots, m$ .

$$V_{kj} = \frac{\sum_{i=1}^n ((\mu_{ik})^w * X_{ij})}{\sum_{i=1}^n (\mu_{ik})^w} \quad (3)$$

5. Calculate the objective function at the  $t$ -th iteration expressed by  $P_t$ .

$$P_t = \sum_{i=1}^n \sum_{k=1}^c \left( \left[ \sum_{j=1}^m (X_{ij} - V_{kj})^2 \right] (\mu_{ik})^w \right) \quad (4)$$

6. Calculate partition matrix change

$$\mu_{ik} = \frac{[\sum_{j=1}^m (x_{ij} - v_{kj})^2]^{-\frac{1}{w-1}}}{\sum_{k=1}^c [\sum_{j=1}^m (x_{ij} - v_{kj})^2]^{-\frac{1}{w-1}}} \quad (5)$$

with  $i = 1, 2, \dots, n$  and  $k = 1, 2, \dots, c$ .

7. Check stop condition

If  $(|P_t - P_{t-1}| < \xi)$  or  $(t > MaxIter)$  then stop, but if  $(|P_t - P_{t-1}| \geq \xi)$  or  $(t \leq MaxIter)$  then repeat step-4.

### Validity of Clustering

The fuzzy C-Means algorithm is often used because it has high accuracy and fast computation time.<sup>19</sup> However, the weakness of Fuzzy C-Means is in determining the optimal number of clusters. The number of clusters must be determined in advance at the initial initiation before conducting the research. Determining the number of clusters that do not match has an impact on clustering results that are not optimal so that it has an impact on decision making. In order to minimize this and optimize the results of clustering, it is necessary to do clustering validity. Clustering validity is done by using the cluster validity index. The validity index measures validity to obtain clustering that can fully explain the data structure.<sup>20</sup> The validity index measures the degree of compactness and separation of data structures in all clusters and finds optimal clustering.<sup>21</sup>

The partition coefficient (PC) is used to check the validity of the clustering results. Partition Coefficient is a medium for evaluating data in each cluster. The partition coefficient value only evaluates the value of the degree of membership regardless of the value of data containing information.<sup>22</sup> The formula used to calculate the validity of the Partition Coefficient is

$$PC = \frac{\sum_{k=1}^c \sum_{i=1}^n \frac{(u_{ik})^2}{n}}{n} \quad (6)$$

Where  $n$  is the number of data,  $c$  is the number of clusters, and  $u_{ik}$  is the membership value of the  $k$ -th data in the  $i$ -th cluster. The value of the validity test results in the range  $[0,1]$ , the value closer to 1 means that the quality of the cluster obtained is getting better.<sup>23</sup>

### Mathematical Connection Ability

In principle, mathematics as a structured and systematic science implies that the concepts and principles in mathematics are interrelated with one another. As an implication, students must have adequate mathematical connection skills in learning mathematics to achieve a meaningful understanding. Mathematical connection ability can link mathematical concepts both between concepts in mathematics itself and associate mathematical concepts with concepts in other fields.<sup>24</sup> The strong connection between mathematical concepts implies that mathematical connection also includes other mathematical aspects or vice versa.

NCTM (2000:274) explains that thinking mathematically involves looking for connections, and making connection builds mathematical understanding. Without connections, students must learn and remember too many isolated concepts and skills. With connections, they can build new understanding on previous knowledge. The important mathematical foci in the middle grades rational numbers, proportionality, and linear relationship are all intimately connected, so as middle-grades students encounter diverse new mathematical content, they have many opportunities to use and make connections.

From those definitions, mathematical connections can be indicated in three aspects: connections between mathematical topics, connections with other disciplines, and connections with students' real-world connections with everyday life. More specifically, the indicator of mathematical connection ability is formulated as follows: 1) looking for relationships between various representative concepts and procedures, 2) understanding the relationship between mathematical topics, 3) using mathematics in other fields of study, 4) understanding the equivalent representative of the same concept, 5) looking for connections from one procedure to another in equivalent representations and 6) using connections between mathematical topics and between mathematical topics and other topics.<sup>25</sup>

## RESEARCH METHODS

This research was conducted at the Anak Pelangi Homeschooling Yogyakarta, with the object of research being the seventh-grade students of SMP. The data used is the mathematical connection test data of students declared accepted at the Anak Pelangi Homeschooling. After scoring based on indicators of mathematical connection ability, the data obtained from the scoring was divided into three categories: low, sufficient, and high. These results are used to determine study groups.

The variables used to determine the division of space or study groups using the Fuzzy C-Means algorithm are as follows:

- 1)  $x_{i1}$  = 1st mathematical connection indicator score
- 2)  $x_{i2}$  = second mathematical connection indicator score
- 3)  $x_{i3}$  = third mathematical connection indicator score
- 4)  $x_{i4}$  = fourth mathematical connection indicator score
- 5)  $x_{i5}$  = fifth mathematical connection indicator score
- 6)  $x_{i6}$  = sixth mathematical connection indicator score

The number of data is 20 students with the  $i$ -th data ( $i = 1, 2, \dots, 20$ ). From the determined category, a criterion importance level is made based on the weight value that has been determined in fuzzy numbers. The suitability rating of each alternative on each criterion is as follows:

- 1) Low (L) = 0
- 2) Average (A) = 0.5
- 3) High (H) = 1

The weight value of each variable is determined in fuzzy numbers. The results of the calculation are carried out based on the steps in the Fuzzy C-Means algorithm.

## RESULTS AND DISCUSSION

The first step is to enter the data to be clustered into the X matrix. The data entered in the X matrix is data that has been weighted based on the research variables as follows:

$$X = \begin{bmatrix} 1 & 0.5 & 1 & 1 & 0.5 & 1 \\ 1 & 0 & 0 & 1 & 0.5 & 1 \\ 1 & 1 & 0.5 & 0.5 & 0.5 & 1 \\ 1 & 1 & 1 & 1 & 0.5 & 1 \\ 1 & 0.5 & 1 & 0.5 & 0 & 1 \\ 0 & 0.5 & 1 & 1 & 0.5 & 1 \\ 1 & 0.5 & 1 & 1 & 0.5 & 0 \\ 0 & 1 & 1 & 0.5 & 0 & 1 \\ 1 & 1 & 0 & 0.5 & 0 & 1 \\ 1 & 1 & 0.5 & 0 & 0.5 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0.5 & 0.5 & 1 & 0 & 1 \\ 0 & 0 & 0.5 & 1 & 0.5 & 1 \\ 0 & 1 & 1 & 0 & 0.5 & 0 \\ 1 & 0 & 1 & 0.5 & 0.5 & 1 \\ 0 & 0.5 & 1 & 0 & 0.5 & 0 \\ 1 & 0 & 1 & 1 & 0.5 & 1 \\ 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0.5 & 1 & 0.5 & 0 \\ 1 & 1 & 0.5 & 1 & 0.5 & 1 \end{bmatrix}$$

The second step is to determine the initial parameters used to solve the problem with the Fuzzy C-Means algorithm. The parameters are the number of clusters ( $c = 2$ ), rank ( $w = 2$ ), maximum iteration ( $MaxIter = 50$ ), the smallest expected error is  $\xi = 0.01$ , the initial objective function ( $P_{0=0}$ ) and iteration initial  $t = 1$ . The number of clusters determined is two, namely the superior cluster for students classified as having high mathematical connection abilities and regular clusters for students who have low mathematical connection abilities.

The third step is to generate a  $U$  matrix with the components  $\mu_{ik}, i = 20; k = 2$ . The value of  $\mu_{ik}$  determined randomly because the number of matrix element values from the column in each row must be 1. The randomly formed  $U$  matrix is as follows:

$$U = \begin{bmatrix} 0.785 & 0.215 \\ 0.672 & 0.328 \\ 0.611 & 0.389 \\ 0.563 & 0.437 \\ 0.166 & 0.834 \\ 0.439 & 0.561 \\ 0.529 & 0.471 \\ 0.822 & 0.178 \\ 0.725 & 0.275 \\ 0.682 & 0.318 \\ 0.331 & 0.669 \\ 0.321 & 0.679 \\ 0.457 & 0.543 \\ 0.736 & 0.264 \\ 0.156 & 0.844 \\ 0.923 & 0.077 \\ 0.163 & 0.837 \\ 0.292 & 0.811 \\ 0.189 & 0.376 \\ 0.524 & 0.257 \end{bmatrix}$$

The  $U$  matrix that has been formed will be used to calculate the cluster center in the next step. In the fourth step, the cluster center will be calculated. Table 1 is obtained from the power of the matrix  $U$  in each column with  $w = 2$  and will be used for multiplication with matrix  $X$ .

**TABLE 1.** Initial Cluster Center

$\mu_{i1}^w$	$\mu_{i1}^w$
0.616	0.046
0.452	0.108
0.373	0.151
0.317	0.191
0.028	0.696
0.193	0.315
0.280	0.222
0.676	0.032
0.526	0.076
0.465	0.101
0.110	0.448
0.103	0.461
0.209	0.295
0.542	0.070
0.024	0.712
0.852	0.006
0.027	0.701
0.085	0.501
0.036	0.658
0.389	0.141
$\Sigma = 6.301$	$\Sigma = 5.929$

Table 2 and 3 are the result of multiplying the  $\mu_{i1}^w$  dan  $\mu_{i2}^w$  in Table 1 with each columns in the  $X$  matrix, the value of  $\Sigma$  obtained will be used to calculate the center of cluster 1 and the center of cluster 2.

**TABLE 2.** Multiplying  $\mu_{i1}^w$  with X Matrix

Data	$\mu_{i1}^w * X_{i1}$	$\mu_{i1}^w * X_{i2}$	$\mu_{i1}^w * X_{i3}$	$\mu_{i1}^w * X_{i4}$	$\mu_{i1}^w * X_{i5}$	$\mu_{i1}^w * X_{i6}$
1	0.616	0.308	0.616	0.616	0.308	0.616
2	0.452	0.000	0.000	0.452	0.226	0.452
3	0.373	0.373	0.187	0.187	0.187	0.373
⋮						⋮
20	0.389	0.389	0.195	0.389	0.195	0.389
$\Sigma$	<b>3.727</b>	<b>4.554</b>	<b>4.341</b>	<b>3.629</b>	<b>2.387</b>	<b>3.932</b>

**TABLE 3.** Multiplying  $\mu_{i2}^w$  with X Matrix

Data	$\mu_{i2}^w * X_{i1}$	$\mu_{i2}^w * X_{i2}$	$\mu_{i2}^w * X_{i3}$	$\mu_{i2}^w * X_{i4}$	$\mu_{i2}^w * X_{i5}$	$\mu_{i2}^w * X_{i6}$
1	0.046	0.023	0.046	0.046	0.023	0.046
2	0.108	0.000	0.000	0.108	0.054	0.108
3	0.151	0.151	0.076	0.076	0.076	0.151
⋮						⋮
20	0.141	0.141	0.071	0.141	0.071	0.141
$\Sigma$	<b>4.751</b>	<b>3.241</b>	<b>3.893</b>	<b>4.919</b>	<b>1.858</b>	<b>3.924</b>

After obtaining the calculations in Tables 2 and 3, the calculation of the centers of clusters 1 and 2. The results for clusters 1 and 2 are presented in Table 4. This value results from the sum of  $\Sigma$  in the  $\mu_{i1}^w$  and  $\mu_{i2}^w$  columns divided by the each  $\Sigma$  value in Table 2 and 3.

**TABLE 4.** Cluster Center Results Iteration 1

$V_{kj}$	1	2	3	4	5	6
1	0.366	0.447	0.426	0.356	0.234	0.386
2	0.484	0.330	0.397	0.501	0.189	0.400

Furthermore, the results of the cluster center in table 4 will be used to find the value of the objective function in the next step. The fifth step is to calculate the value of the objective function  $P_1$  based on the Fuzzy C-Means algorithm.

**TABLE 5.** The Calculation of  $C_1$

Data	$C_1$						$\Sigma C_1$	$\Sigma C_1 * \mu_{i1}^w$
	$(X_{i1} - V_{i1})^2$	$(X_{i2} - V_{i1})^2$	$(X_{i3} - V_{i1})^2$	$(X_{i4} - V_{i1})^2$	$(X_{i5} - V_{i1})^2$	$(X_{i6} - V_{i1})^2$		
1	0.402	0.003	0.329	0.414	0.071	0.377	1.596	1.253
2	0.402	0.200	0.182	0.414	0.071	0.377	1.646	1.106
3	0.402	0.306	0.005	0.021	0.071	0.377	1.181	0.722
⋮								⋮
20	0.402	0.306	0.005	0.414	0.071	0.377	1.575	0.983

**TABLE 6.** The Calculation of  $C_2$

Data	$C_2$						$\Sigma C_2$	$\Sigma C_2 * \mu_{i2}^w$
	$(X_{i1} - V_{i2})^2$	$(X_{i2} - V_{i2})^2$	$(X_{i3} - V_{i2})^2$	$(X_{i4} - V_{i2})^2$	$(X_{i5} - V_{i2})^2$	$(X_{i6} - V_{i2})^2$		
1	0.192	0.109	0.048	0.037	0.182	0.047	0.615	0.132
2	0.142	0.109	0.003	0.251	0.036	0.003	0.544	0.178
3	0.111	0.109	0.001	0.016	0.000	0.045	0.282	0.110
⋮								⋮
20	0.117	0.109	0.000	0.013	0.000	0.000	0.239	0.090

Furthermore in Table 7, the calculation of the objective function for the first iteration is given. The result is obtained from the sum of the columns  $\Sigma C_1 * \mu_{i1}^w$  and  $\Sigma C_2 * \mu_{i2}^w$ .

**TABLE 7.** Objective Function Calculation Results

<b>Data</b>	$\sum C_1 * \mu_{i1}^w + \sum C_2 * \mu_{i2}^w$
1	1.385
2	1.284
3	0.832
⋮	⋮
20	1.073
<b>Σ</b>	<b>18.894</b>

The sixth step is to find a new  $U$  matrix by following the Fuzzy C-Means Algorithm. For the first column, the results are obtained from column  $\sum C_1$  divided by the sum of column  $\sum C_1$  and  $\sum C_2$ . The second column are obtained from column  $\sum C_2$  divide by the sum of column  $\sum C_1$  and column  $\sum C_2$ . Then the  $U$  matrix is obtained with the new membership degrees as follows:

$$U = \begin{bmatrix} 0.722 & 0.278 \\ 0.752 & 0.248 \\ 0.807 & 0.193 \\ 0.880 & 0.120 \\ 0.628 & 0.372 \\ 0.726 & 0.274 \\ 0.799 & 0.201 \\ 0.622 & 0.378 \\ 0.794 & 0.206 \\ 0.714 & 0.286 \\ 0.764 & 0.236 \\ 0.632 & 0.368 \\ 0.668 & 0.332 \\ 0.606 & 0.394 \\ 0.657 & 0.343 \\ 0.425 & 0.575 \\ 0.717 & 0.283 \\ 0.746 & 0.254 \\ 0.675 & 0.325 \\ 0.868 & 0.132 \end{bmatrix}$$

In the seventh step, it will be checked whether the condition is qualified to stop where the values is ( $|P_t - P_{t-1}| < \xi$ ) or ( $t > MaxIter$ ). Because  $18.894 > 0.01$ , the fourth step will be repeated until the conditions for stopping are met. For effectiveness reasons, Fuzzy C-Means can be run on the Matlab program.

The following are the results of grouping based on the degree of membership in the last iteration, namely the 15th iteration with a value of ( $|P_{15} - P_{14}|$ , i.e.,  $|9.179517 - 9.179523| < 0.01$ ). From the calculations in table 8, it can be concluded that there are nine students included in cluster 1 (Superior Class), and 11 students are included in cluster 2 (Regular Class).

**TABLE 8.** Clustering Results

<b>Student</b>	<b>Membership Degree</b>		<b>Cluster</b>	<b>Class</b>
	<b>Cluster 1</b>	<b>Cluster 2</b>		
1	0.214	0.786	2	Regular
2	0.407	0.593	2	Regular
3	0.504	0.496	1	Superior
⋮				⋮
20	0.460	0.540	2	Regular

To check the validity of the clustering results as an evaluation of the data in each cluster by using the calculation of the partition coefficient obtained 0.830. From obtaining the validity value, it can be said that the clustering results are classified as good because the value of the validity test is close to 1. The complete results of the validity test for each iteration of clustering are shown in table 9.

**TABLE 9.** The Validity of Clustering

<b>Iteration</b>	<b>Validity</b>
1	0.483
2	0.501
3	0.620
4	0.642
5	0.650
6	0.670
7	0.688
8	0.692
9	0.700
10	0.765
11	0.790
12	0.800
13	0.818
14	0.824
15	0.830

## CONCLUSION

Based on the calculation results, it can be concluded that as many as 9 out of 20 students of class VII Anak Pelangi Homeschooling are included in the group of students who have good mathematical connection abilities or above average, so that nine students are members of the superior study group. Eleven students are members of the group. Study regularly. The clustering validity test as an evaluation of the data in each cluster that was carried out using the partition coefficient resulted in a value of 0.830. It can be said that the clustering results belong to the good category because the validity value is close to 1.

## ACKNOWLEDGMENTS

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# Automatic addition of hydroponic reservoir water using Fuzzy Logic

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**Abstract.** Hydroponics is one way to grow plants on a large or small scale without requiring land. This way of farming can be cultivated in urban areas. However, this system has several drawbacks. Namely, it requires a controlled environment, especially watering, to avoid a decrease in plant quality until the plant wilts. This is one of the obstacles, especially for people in urban areas with dense activities. This study aims to design a control system for an automatic water addition machine for hydroponic tendons using the Mamdani method of fuzzy logic. Air temperature, humidity, and nutrient concentration are parameters that will be considered to determine the amount of water added to the hydroponic reservoir. The implementation of the Fuzzy Inference System with the Mamdani Method can be used to design a control system for adding water to hydroponic reservoirs.

## INTRODUCTION

In the modern era now, human lives are assisted by the technology about mathematics, one of them in the agricultural sector hydroponics. Hydroponics is agricultural cultivation without using soil media, so hydroponics is an agricultural activity carried out with water as a medium to replace soil [1]. With these media, planting using hydroponics is very suitable for cultivation in urban areas. Hydroponic planting requires control from the owner, especially in maintaining the environment in ideal conditions. This control is essential because maintenance is one of the success factors for hydroponic farming [2]. There are several things that need to be maintained in hydroponic planting, namely the condition of water pH, nutrient concentration, water level, air temperature, air humidity, nutrient water temperature, and plant age [1][3]. This requires the owner to carry out periodic checks and then make decisions to maintain ideal conditions. Decisions are taken, such as adding a solution to raise and lower the pH, changing the nutrient solution, changing the flow rate of nutrients, and adding water to the hydroponic nutrient reservoir.

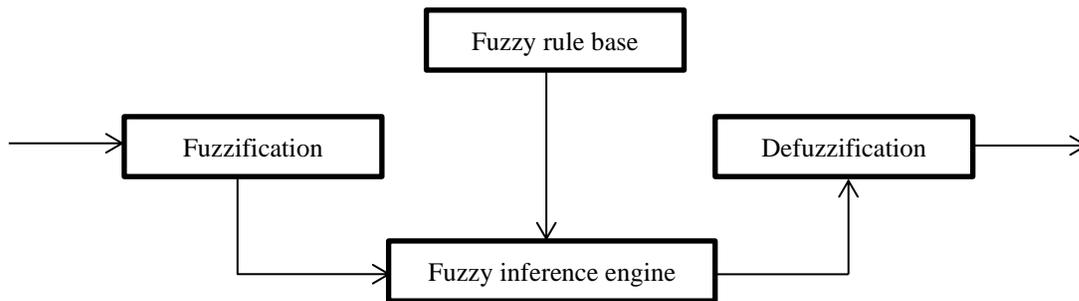
The activity that is most often carried out is the addition of fresh water in hydroponic reservoirs. This activity can be done more than once a day, but this is an obstacle for owners who have other busy activities. So that one technology that is very helpful in hydroponic farming is an automatic water addition device in hydroponic reservoirs. In general, automatic addition of water is done by adjusting the time of adding water with a standard water volume setting. In fact, to achieve maximum results, it is best to add water to hydroponic reservoirs. It is necessary to pay attention to several other ideal conditions factors such as air temperature, humidity, and nutrient density.

Plants will grow with good quality if they are able to absorb nutrients from nutrients properly. Plants will absorb nutrients well if they are at ideal temperatures ranging from 18 to 25 degrees Celsius and in ideal humidity ranging from 67% to 72%, with nutrient concentrations for vegetable crops ranging from 1100 to 1400 ppm [1][4]. If the temperature is high and the humidity is low, the plants will evaporate excessively and result in an increase in the volume of water absorption. At the same time, the nutrient water also undergoes evaporation due to the rising water

temperature. The existence of a high evaporation process will reduce the volume of water in the hydroponic reservoir so that the concentration of nutrients in the reservoir increases. On the one hand, nutrient concentration is one of the most influential factors in hydroponic success because if nutrients are too concentrated, plants will experience stress. On the one hand, if the nutrient water has a low concentration, the plant will lack nutrients for growth [5].

Based on these conditions, a control system will be made on the automatic water addition machine in the hydroponic reservoir to determine the volume of water added by taking into account the parameters of air temperature, humidity, and nutrient density with a fuzzy system. It can help the owner to hydroponic reservoir walk with the maximum and do not disturb other activities

A fuzzy system is a system consisting of a series of fuzzification processes, fuzzy rule base, fuzzy inference engine, and defuzzification, as shown in Figure 1. The fuzzy system is based on fuzzy logic Mamdani Method. Fuzzy logic is based on expert knowledge in a field to determine rules [6].



**FIGURE 1.** Formation of Fuzzy System

## METHOD

### Fuzzification

Fuzzification is a mapping that maps the point  $x^* \in U \subset R^n$  to a fuzzy set  $A$  at  $U$ . It means the point  $x^* \in U \subset R^n$  mapped use fuzzification to a fuzzy set  $A$  at  $U$ . There are three types of fuzzified, namely singleton, Gaussian and triangular. In this study, a triangular fuzzifier with the following membership functions will be used [6][7],

$$\mu_{A'}(x) = \begin{cases} \left(1 - \frac{|x_1 - x_1^*|}{b_1}\right) * \dots * \left(1 - \frac{|x_n - x_n^*|}{b_n}\right), & \text{if } |x_i - x_i^*| \leq b_i, i = 1, 2, \dots, n \\ 0, & \text{another} \end{cases}$$

Equations 1

### Fuzzy Rule Base

The number of rules that are formed depends on the number of inputs and outputs specified. The fuzzy rule base consists of the "If – Then" rules which are shown by the following logic [7].

$$"Ru^{(1)}: \text{If } x_1 \text{ is } A_1^1 \text{ and } \dots \text{ and } x_n \text{ is } A_n^1 \text{ Then } y \text{ is } B^1"$$

Equations 2

### Fuzzy Infusion Machine

The inference is a transformation process from an input in the fuzzy domain to an output (control signal) in the fuzzy domain. The transformation process in the inference section uses fuzzy rules that have been formed [8]. In this study, the inference used is the slice operation (min).

## Defuzzification

Defuzzification is a mapping from fuzzy set B in  $V \subset \mathbb{R}$  to a point with real value  $y \in V$  [6]. There are three types of defuzzification, namely the center of gravity, the average center, and the maximum. In this study, a center of gravity defuzzifier with the following membership function will be used [7].

$$y^* = \frac{\int_v y \mu_B(y) dy}{\int_v \mu_B(y) dy}$$

Equations 3

## SYSTEM DESIGN

### Specifying Input

There are three parameter input will be examined to determine the additional water at hydroponics reservoir, namely air temperature (t), humidity (h), and nutrient concentration (d). Temperature (t) is divided into three categories, namely  $t_1$ ,  $t_2$ , and  $t_3$  functions membership or graphic representation based on temperature:

$$t_1(x) = \begin{cases} 1 & ; x \leq 12 \\ \frac{22-x}{10} & ; 12 \leq x \leq 22 \\ 0 & ; \text{other} \end{cases} \quad t_2(x) = \begin{cases} \frac{x-12}{10} & ; 12 \leq x \leq 22 \\ \frac{32-x}{10} & ; 22 \leq x \leq 32 \\ 0 & ; \text{other} \end{cases} \quad t_3(x) = \begin{cases} 0 & ; x \leq 22 \\ \frac{x-22}{10} & ; 22 \leq x \leq 32 \\ 1 & ; x \geq 32 \end{cases}$$

Equations 4

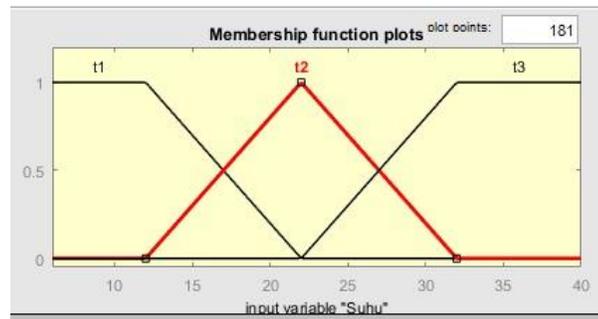
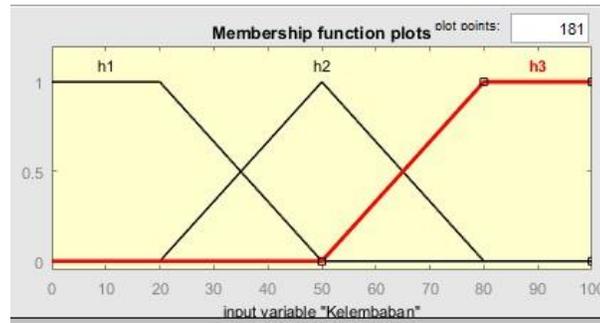


FIGURE 2. Representation of temperature

Air humidity (h) is divided into three, namely  $h_1$ ,  $h_2$ , and  $h_3$ , with membership function

$$h_1(x) = \begin{cases} 1 & ; x \leq 20 \\ \frac{50-x}{30} & ; 20 \leq x \leq 50 \\ 0 & ; \text{other} \end{cases} \quad h_2(x) = \begin{cases} \frac{x-20}{30} & ; 20 \leq x \leq 50 \\ \frac{80-x}{30} & ; 50 \leq x \leq 80 \\ 0 & ; \text{other} \end{cases} \quad h_3(x) = \begin{cases} 0 & ; x \leq 50 \\ \frac{x-50}{30} & ; 50 \leq x \leq 80 \\ 1 & ; x \geq 80 \end{cases}$$

Equations 5

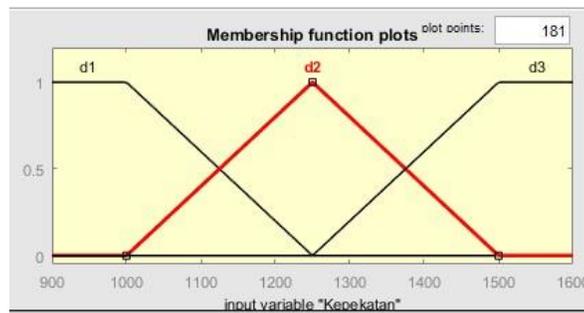


**FIGURE 3.** Representation of air humidity

Nutrient concentration ( $d$ ) is divided into three, namely  $d_1$ ,  $d_2$ , and  $d_3$ , with membership function.

$$d_1(x) = \begin{cases} 1 & ; x \leq 1000 \\ \frac{1250 - x}{250} & ; 1000 \leq x \leq 1250 \\ 0 & ; \text{other} \end{cases} \quad d_2(x) = \begin{cases} \frac{x - 1000}{250} & ; 1000 \leq x \leq 1250 \\ \frac{1500 - x}{250} & ; 1250 \leq x \leq 1500 \\ 0 & ; \text{other} \end{cases} \quad d_3(x) = \begin{cases} 1 & ; x \geq 1500 \\ \frac{x - 1250}{250} & ; 1250 \leq x \leq 1500 \\ 0 & ; \text{other} \end{cases}$$

Equations 6



**FIGURE 4.** Representation of nutrient concentration

### Specifying Output

The output of the control system is the volume of water ( $v$ ) which is divided into five  $v_1$ ,  $v_2$ ,  $v_3$ ,  $v_4$ , and  $v_5$  with membership functions:

$$v_1(x) = \begin{cases} \frac{2,5-x}{2,5} & ; 0 \leq x \leq 2,5 \\ 0 & ; \text{other} \end{cases}$$

$$v_2(x) = \begin{cases} \frac{x}{2,5} & ; 0 \leq x \leq 2,5 \\ \frac{5-x}{2,5} & ; 2,5 \leq x \leq 5 \\ 0 & ; \text{other} \end{cases}$$

$$v_3(x) = \begin{cases} \frac{x-2,5}{2,5} & ; 2,5 \leq x \leq 5 \\ \frac{7,5-x}{2,5} & ; 5 \leq x \leq 7,5 \\ 0 & ; \text{other} \end{cases}$$

$$v_4(x) = \begin{cases} \frac{x-5}{2,5} & ; 5 \leq x \leq 7,5 \\ \frac{10-x}{2,5} & ; 7,5 \leq x \leq 10 \\ 0 & ; \text{other} \end{cases}$$

$$v_5(x) = \begin{cases} \frac{x-7,5}{2,5} & ; 7,5 \leq x \leq 10 \\ 0 & ; \text{other} \end{cases}$$

Equations 7

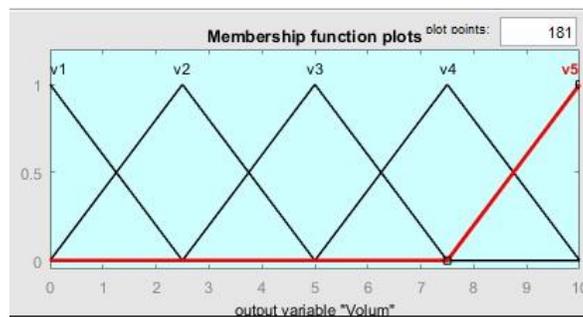


FIGURE 5. Water volume representation

### Determining the Rules

The rule follows the form: "If t = ... and h = ... and d = ... then v = ...". The overall rules formed are shown in table 1.

## IMPLEMENTATION OF CONTROL SYSTEM

Suppose the input values for air temperature, humidity, and nutrient density are 30°, 74%, and 1000 ppm, respectively. For air temperature, the membership degrees of low, medium, and high air temperatures are 0; 0.2, and 0.8. For air humidity, the membership degrees of low, medium, and high humidity are 0; 0.2, and 0.8. For nutrient concentrations, the membership degrees of the low, medium, and high nutrient concentrations are 1; 0, and 0. Based on these inputs, there are four rules in table 2 that will be processed.

TABLE 1. Fuzzy rules

Number	Input			Output
	Air temperature	Air Humidity	Nutrient Concentration	Water Volume
1	$t_1$	$h_1$	$d_1$	$v_1$
2	$t_1$	$h_1$	$d_2$	$v_2$
3	$t_1$	$h_1$	$d_3$	$v_4$
4	$t_1$	$h_2$	$d_1$	$v_1$
5	$t_1$	$h_2$	$d_2$	$v_1$
6	$t_1$	$h_2$	$d_3$	$v_3$
7	$t_1$	$h_3$	$d_1$	$v_2$
8	$t_1$	$h_3$	$d_2$	$v_2$

Number	Input			Output
	Air temperature	Air Humidity	Nutrient Concentration	Water Volume
9	$t_1$	$h_3$	$d_3$	$v_3$
10	$t_2$	$h_1$	$d_1$	$v_2$
11	$t_2$	$h_1$	$d_2$	$v_3$
12	$t_2$	$h_1$	$d_3$	$v_4$
13	$t_2$	$h_2$	$d_1$	$v_2$
14	$t_2$	$h_2$	$d_2$	$v_2$
15	$t_2$	$h_2$	$d_3$	$v_3$
16	$t_2$	$h_3$	$d_1$	$v_1$
17	$t_2$	$h_3$	$d_2$	$v_1$
18	$t_2$	$h_3$	$d_3$	$v_2$
19	$t_3$	$h_1$	$d_1$	$v_4$
20	$t_3$	$h_1$	$d_2$	$v_5$
21	$t_3$	$h_1$	$d_3$	$v_5$
22	$t_3$	$h_2$	$d_1$	$v_3$
23	$t_3$	$h_2$	$d_2$	$v_4$
24	$t_3$	$h_2$	$d_3$	$v_5$
25	$t_3$	$h_3$	$d_1$	$v_3$
26	$t_3$	$h_3$	$d_2$	$v_4$
27	$t_3$	$h_3$	$d_3$	$v_4$

TABLE 2. Processed rules

Number	Input			Output
	Air temperature	Air Humidity	Nutrient Concentration	Water volume
13	0,2	0,2	1	$v_2$
16	0,2	0,8	1	$v_1$
22	0,8	0,2	1	$v_3$
25	0,8	0,8	1	$v_3$

After getting the processed rules, the data is then processed in the inference engine. Based on these rules, the inference engine produces the following functions.

$$\int_0^{7,5} C_{t,h,d}(v)dx = \int_0^3 (0,2)dx + \int_3^{4,5} \left( \frac{x-2,5}{2,5} \right) dx + \int_{4,5}^{5,5} (0,8)dx + \int_{5,5}^{7,5} \left( \frac{7,5-x}{2,5} \right) dx$$

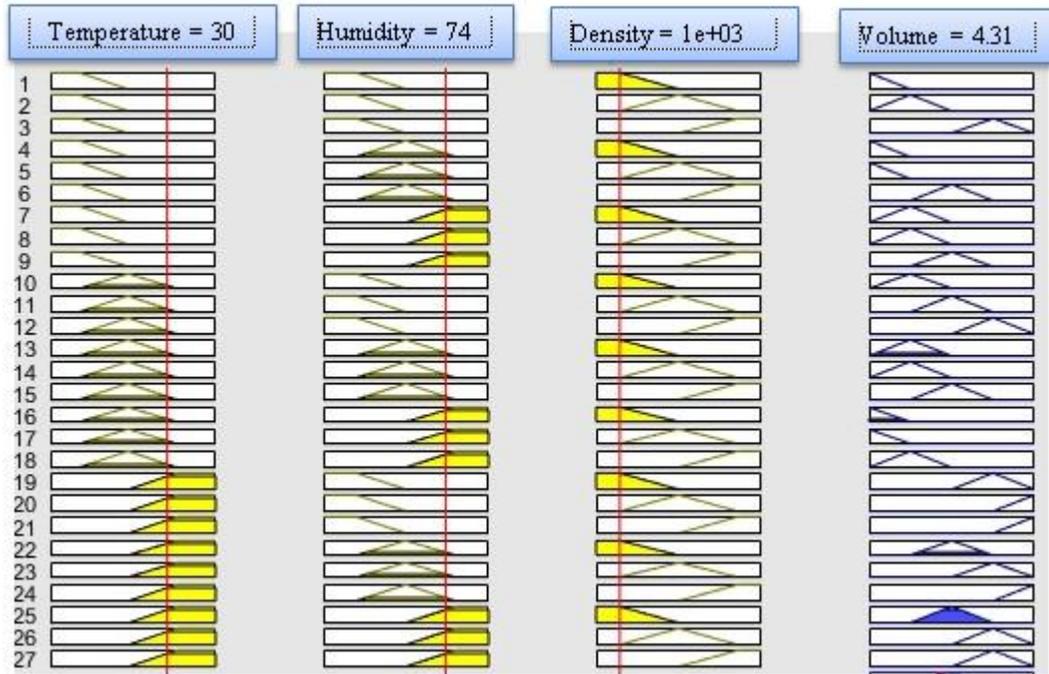
Equations 8

Then proceed with the defuzzification process with the center of gravity, and the following calculations are obtained.

$$v = \frac{\int_0^{7,5} x C_{t,h,d}(v)dx}{\int_0^{7,5} C_{t,h,d}(v)dx} = 4,324745763$$

Equations 9

Based on manual calculations, the output volume of water is 4.324745763 liters. Then do the calculations with the help of Matlab to make comparisons. Figure 6 below shows the results of calculations using Matlab.



**FIGURE 6.** Calculations with Matlab

Calculations with the help of Matlab show the output volume of water as much as 4.31 liters. So it can be seen that manual calculations and Matlab calculations show values that are not much different.

## CONCLUSION

The implementation of the Fuzzy Inference System with the Mamdani Method can be used to design a control system for adding water to hydroponic reservoirs. The input parameters used are air temperature, humidity, and nutrient density. The three parameters are divided into three, namely low, medium, and high. The output from the system is the volume of water that must be added. The output is divided into five, namely  $v_1$ ,  $v_2$ ,  $v_3$ ,  $v_4$ , and  $v_5$ . Based on the number of inputs and outputs, the system has 27 rules then the center of gravity method is used for defuzzification.

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# Edutourism Learning in Bergas Kidul to Improve Students' Analytical Ability

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**Abstract.** Tourism-based science education (science edutourism ) at universities still needs to be improved in terms of students' analytical skills. Students in the era of the industrial revolution 4.0 are required to be more critical and creative in solving problems in the surrounding environment. One of the edutourism-based learning activities is in the tourist village of Bergas Kidul. This village has exotic natural wealth supported by handicrafts from the local community. Therefore, this village can be used as a model of science edutourism learning. The carrying capacity of science edutourism learning for students requires environmental observation in improving student analytical skills. This study aims to determine the effect of science edutourism learning to improve students' analytical skills. This research contributes in forming students' character to love environmental (soft skills) and the ability to analyze problems in the environment. The results showed that the level of students' analytical skills in learning science edutourism has a high category. This is shown by the students' result in the science entrepreneurship course which involves learning science edutourism with very good category results. Learning science edutourism can be used to train students to be entrepreneurs and develop innovative ideas that students have.

## INTRODUCTION

Science learning in the era of the industrial revolution 4.0 is required to be more critical and creative in solving problems in the surrounding environment. Science learning really requires critical thinking skills and creative attitudes because in the process it takes effort to understand the universe through precise observations on the target, as well as using procedures and explained by reasoning so as to get conclusions in a lesson (Amalia & Bintari, 2016). Based on this, to meet the demands of the 4.0 revolution, learning is needed that makes students come into direct contact with nature so that students recognize and analyze things appropriately. This is needed to avoid the rote nature of students related to science materials such as science entrepreneurship, so they can apply concepts from the material that has been studied and train them to think critically and creatively in analyzing problems. Based on this, applicative learning is needed that can explore two or more subjects so that it is not only limited to rote memorization.

Science edutourism learning is a learning process carried out in tourism activities to become an effective and creative learning method as well as an alternative unique and interesting learning method. Educational tourism is an effort to increase new knowledge through tourism activities and direct observation with nature (Novianti et al., 2020). In addition, edutourism science learning emphasizes one's motor and sensory education to improve the function of the five senses (Hermawan, 2018). This edutourism science learning combines material with direct observation of environmental conditions that can hone logical (causal), creative, and exploratory thinking in a person. The advantage of science edutourism is that children practice more, explore, and learn by doing so that fun learning is created and instills the character of love for the surrounding nature so that it will be suitable if applied to science entrepreneurship courses (Wijaya, 2014).

The advantages of learning that combine material with an exploratory activity such as edutourism are able to increase the enthusiasm of tourists or students and at the same time provide environmental insight that is in accordance with integrated thematic learning in the 2013 Curriculum (Tosida et al., 2018). The form of science edutourism learning has 2 stages, namely before and during learning. The learning process applied is that students study the material at home before class starts in the form of doing assignments, discussing problems or material that the student has not known. When doing assignments in lectures or classes, they experience difficulties, they can be discussed with friends or consult with the lecturer during the edutourism stage, namely interacting with the environment so that students can directly analyze the problems they face and produce solutions (Yulietri et al., 2015). The use of unique models such as science edutourism in learning is very efficient in time management, where in the conventional model the learning time runs out to explain the material, while in the science edutourism model time is managed properly and

diverted to discuss and make observations and even analyze directly the problems that exist in the surrounding environment, so that it can strengthen learning concepts and improve long term memory (Rindaningsih, 2018).

Learning with science edutourism has been widely applied in learning. In addition to training students to analyze and solve a problem, this learning also trains the nature of independence, activeness, and critical thinking and supports a curriculum that implements a student center (Hamonangan & Sudarma, 2017). In addition, this learning can be done freely by instilling a love for the environment so that it will affect student behavior and assessments about the importance of paying attention to the surrounding environment (Yusuf et al., 2016). This is needed by an entrepreneur who is good at acting and exploring without damaging or disturbing the balance of the surrounding environment in its application.

**METHOD**

This research is a classroom action research that aims to improve the results of the analysis of science students in the science entrepreneurship course by using the science edutourism learning model. The research design used is an action research model design, in the form of a cycle. This research was carried out in three cycles, and the steps in each cycle consisted of planning, implementing, observing, and reflecting.

Based on Wijayanti's research (2013) classroom action research is a recycled research conducted by teachers to improve the learning process. The research was conducted with the root of the problem actually faced by students (concrete problems in the classroom, felt by most students, and appeared continuously). The research was carried out in 3 cycles. If after the first cycle has not reached the success indicator, then the second cycle is continued. The image visualization of the classroom action research process looks as follows:

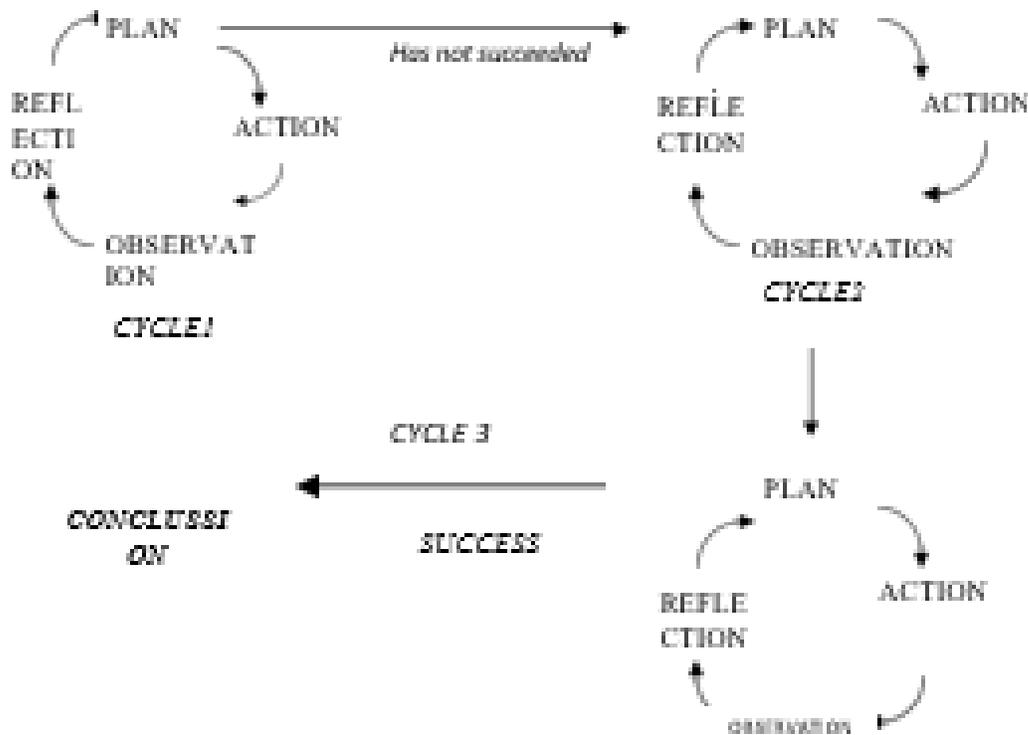


Figure 1. Classroom Action Research Process

### Early Reflection

Initial reflection includes an evaluation of the results of initial observations which include the state of learning, lecturer performance, student performance. Researchers analyzed the problems that existed in the previous learning.

#### Cycle 1

##### a.) Action plan

This action plan consists of (a) compiling a Semester Learning Plan (RPS) in which the science edutourism model is applied; (b) Prepare a test to measure the results of student analysis. At the first meeting of cycle 1, the material taught was to understand the concept of entrepreneurship in the science field.

##### b.) Implementation of Action

At this stage, researchers and observers implement all the action plans that have been prepared. RPS is implemented by lecturers as researchers who act as facilitators in lecture activities. At the final stage of the cycle, students are given a test to measure cognitive abilities in the form of problem analysis skills.

##### c.) Test

The test is carried out by the lecturer as a researcher. Test activities are carried out by giving questions about cognitive abilities during the lecture process.

##### d.) Reflection I

The results of the measurement data during the implementation of the actions obtained by measuring through tests are used as the basis for reflection I. Reflections are carried out by researchers and observers by analyzing, and evaluating the collected data. The results of reflection I are used as a guide to develop an action plan II.

#### Cycle 2 and 3

The stages of research in cycles II and III are similar to cycle I, namely action plans, implementation of actions, observations, and reflections. Action plan II is based on the findings of observation and reflection I. Cycle III is based on the findings of observation and reflection

II. Activities in cycle II were given additional actions in the form of additional activity guides in the form of practicum during lectures and in cycle III were added learning videos before online learning. The limitation in measuring the results of improving student analysis is that at least 31 out of 36 students have achieved or exceeded the value according to completeness ( $B = 71$ ) so the research is considered successful.

## RESULTS AND DISCUSSION

This classroom action research was conducted by the Science Education Study Program, Integrated Science Department, FMIPA UNNES. The research subjects were students of class A who took the science entrepreneurship course which consisted of 36 students.

### Pre Cycle

The initial activity carried out was to make observations to find out the results of students' analytical skills when studying entrepreneurship science. The researcher observed that the lecture process for the initial students which took place offline was changed online using the elena system ([elena.unnes.ac.id](http://elena.unnes.ac.id)) in discussions and presentations due to the covid-19 pandemic. Based on the observations made in the study, learning activities were only dominated by a few active students and when the pretest was carried out, 70% of the students had not exceeded the score according to completeness ( $B=71$ ). Based on these results, treatment was given with an innovative learning model using science edutourism. CAR activities are carried out in the science entrepreneurship course which consists of 4 sub-materials and is divided into 3 meetings. The sub-materials are understanding the concept of science entrepreneurship in the field of science, understanding the studies and prerequisites for being an entrepreneur as a science teacher, and understanding the concepts of conservation-based entrepreneurship and applied science.

## Cycle I

The learning action in cycle I was carried out in 1 meeting. The main material studied in the first cycle of research is understanding the concept of science entrepreneurship in the science field. The results of observations related to the improvement of student analysis in the first cycle obtained an average value of 65.2 out of a total value of 100. Based on the percentage of achievement of student analysis results in the first cycle, there were already several students who could achieve scores above the minimum standard of 71, but the data was still dominated by students who score below the minimum standard.

Based on the results of the descriptive analysis of the students' cognitive learning outcomes in the first cycle, the results of the students' level of analysis were not maximized. This is because the science edutourism learning model is a new thing for students, so students are still not optimal and need adaptation to the learning to improve the results of their analysis. This can be seen from the results of the analysis of the descriptive reports made. In the description of the report, there are still many mistakes in providing an understanding of the concept of science entrepreneurship.

Based on the data analysis in the first cycle, the researchers reflected on the factors that caused the less than optimal results of student analysis in learning using the science edutourism model, namely:

- a. Lack of direct technical guidance in the implementation of learning. This can be seen from the many students who ask about the technical learning that is taking place.
- b. Observations were carried out independently using elena so that there was no discussion forum between students, thus limiting the discovery of the concept of knowledge gained.

Based on the results of these reflections, the corrective steps taken in cycle II are as follows:

- a. Instructions related to learning are carried out directly through the Zoom Meet application to make it clearer and more focused. Be it at the stage before learning, during learning and after learning using science education and working on questions in every meeting on the google classroom given by the lecturer.
- b. During the learning process, a question and answer forum or discussion is provided so that students can share or share their initial knowledge and share the results of the analysis obtained.

Based on the results of the analysis above, the lecturer made improvements in teaching the next material, namely the sub-material of understanding the study and the prerequisites as an entrepreneur as a science teacher which was applied in cycle II and updating learning activities or lectures as expected so that the analytical skills of science students, especially those who took the subject science entrepreneurship courses can increase.

## Cycle II

The results of the research in cycle I as a whole have not reached the indicators of success and there are still some things that need to be improved and improved. Based on this, the researcher continued the research in cycle II. The activities carried out in the second cycle are almost the same as the first cycle. Observation of the results of the analysis in the second cycle obtained an average value of 76.4 out of a total value of 100. It has been seen that there is an increase in the percentage of student analysis results in the second cycle of 11.2% compared to the achievement in cycle I. The increase in the value of the analysis results in cycle II is also reflected in more active lecture activities and students also seem to have adapted to the science education model.

Based on the results of the second cycle, it is still possible to improve the results of student analysis due to several factors, namely the follow-up to the discussion in the next submaterial. There is a follow-up that makes students more challenged after running the science edutourism model is the right thing. This allows the results of the analysis to be further improved. Even though there was an increase in the results of the analysis, cycle III was still carried out to strengthen the research results and ensure that the results obtained were really good. Based on this, it is necessary to reflect on cycle II first for improvement in cycle III, as follows:

- a. During the learning process, the lecturer must be able to organize time well and can act as a learning facilitator.

b. Discussion and question and answer activities are still carried out either directly using zoom meet, so that all students can be actively involved and account for the results of discussions and concepts that have been built.

c. It is necessary to add interesting videos before and during learning to discuss the science education model to increase student understanding and share the results of each student's analysis.

Based on the results of the analysis and reflection above, the lecturer made improvements and stabilization in teaching the next material, namely the sub-material of understanding the concept of conservation-based entrepreneurship and science which was applied in cycle III and updating learning activities as expected so that the results of the analysis could improve.

#### Cycle III

The results of the third cycle research as a whole have reached the indicators of success. The activities carried out in cycle III were almost the same as in cycle II. The results of the observation of the analysis results in the third cycle obtained an average value of 94.8 out of a total value of 100. There was an increase in the percentage of student analysis results in the third cycle of 18.4% compared to the average value in the second cycle.

Class action research in the Science Education Study Program, especially students who take the class A science entrepreneurship course, occurs in three cycles. Observations were made on the results of the analysis for each cycle. Observations were made with tests or cognitive questions. The results of the analysis can be seen in Figure 2. Based on the results of the descriptive analysis of the third cycle, it shows an increase in the value of the second cycle. Comparison between cycles shows an increase in each cycle, which peaks in cycle III. The increase in the results of the analysis looks significant as indicated by the percentage increase in the third cycle of 29.6% compared to the average value in the first cycle.

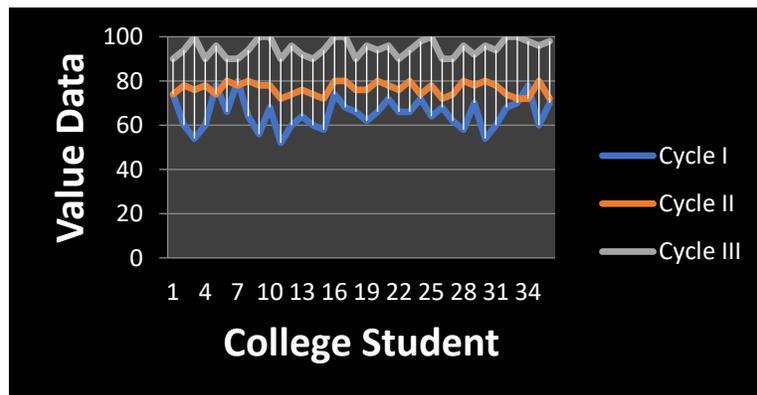


Figure 2. Results of Improved Analysis on Cycle

Figure 2 shows the results of increasing student analysis between cycles showing various results and there is an increase between each cycle. This can be seen from the cycle III graph which is at a value of 90 which is above the minimum standard value of completeness which is 71. The average value of each cycle can be seen in Figure 3 below:

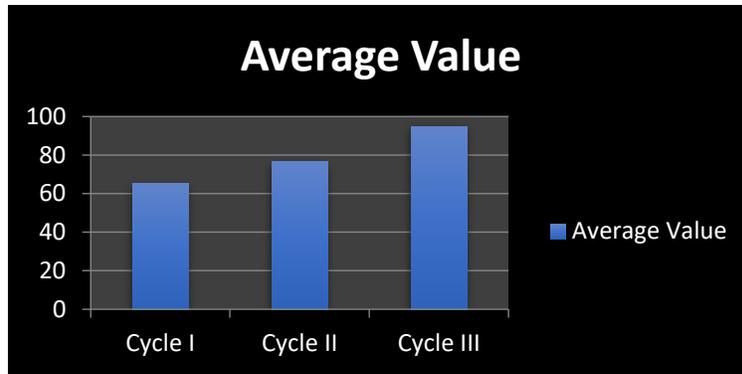


Figure 3. Graph of the Average Value of Inter-Cycle Analysis Results

Figure 3. shows that there is an increase in the average analysis result between cycles. The highest average score was in the third cycle reaching 94.8 out of a total value of 100. The increase in the analysis results in each cycle indicated that the quality of student learning activities began to increase in each cycle. The results of observations made by researchers indicate that the implementation of learning with the application of the science edutourism learning model can provide better results. The existence of this learning model and media makes students more active in understanding entrepreneurship science lecture material and improves student analysis results. In addition, it also improves understanding of concepts so that it creates long-term memory rather than just memorizing which creates short-term memory because it is supported by learning to interact with nature directly and giving the character of loving the environment. Based on the results of analysis and reflection from 3 cycles, this research is considered complete and successful because the indicator of achievement of the results of the analysis increased significantly, namely 29.6% from the average value in cycle I to cycle III, students have actively participated in learning activities and got more than The minimum completeness score is 71.

## CONCLUSIONS

Based on the results of the research and discussion that have been presented, it can be concluded that the implementation of learning with the application of science edutourism can improve the analysis results of students of the Science Education Study Program, especially those who take science entrepreneurship courses. The application of science edutourism can improve the results of the analysis with the average value in the first cycle reaching 65.2 and an increase of 11.2% in the second cycle reaching an average value of 76.4 then an increase again in the third cycle of 18.4% from the second cycle which is at an average value of 93.8. The science edutourism model is suitable for use in lectures, especially for science entrepreneurship courses because it is proven to be able to improve student analysis results.

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# The Antecedents and Consequences of Personal Reputation: An Agenda for Future Research

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**Abstract.** The purpose of this paper is to develop and validate a proposed conceptual framework on personal reputation in an organizational context. A literature review was analyzed to identify the key variables of personal reputation. It is believed that a reliable and valid multidimensional framework was obtained to measure personal reputation. Three dimensions of personal reputation are needed for self-esteem, need to belong, and desire for rewards. Interestingly, mediating variables such as gossip and legitimacy are positively influenced by the personal reputation of career success. The study is among the first attempt to develop a proposed conceptual framework of online personal reputation. The study contributes to the personal reputation literature in the sense of improving career success for the critical inquiry of the impression management.

## INTRODUCTION

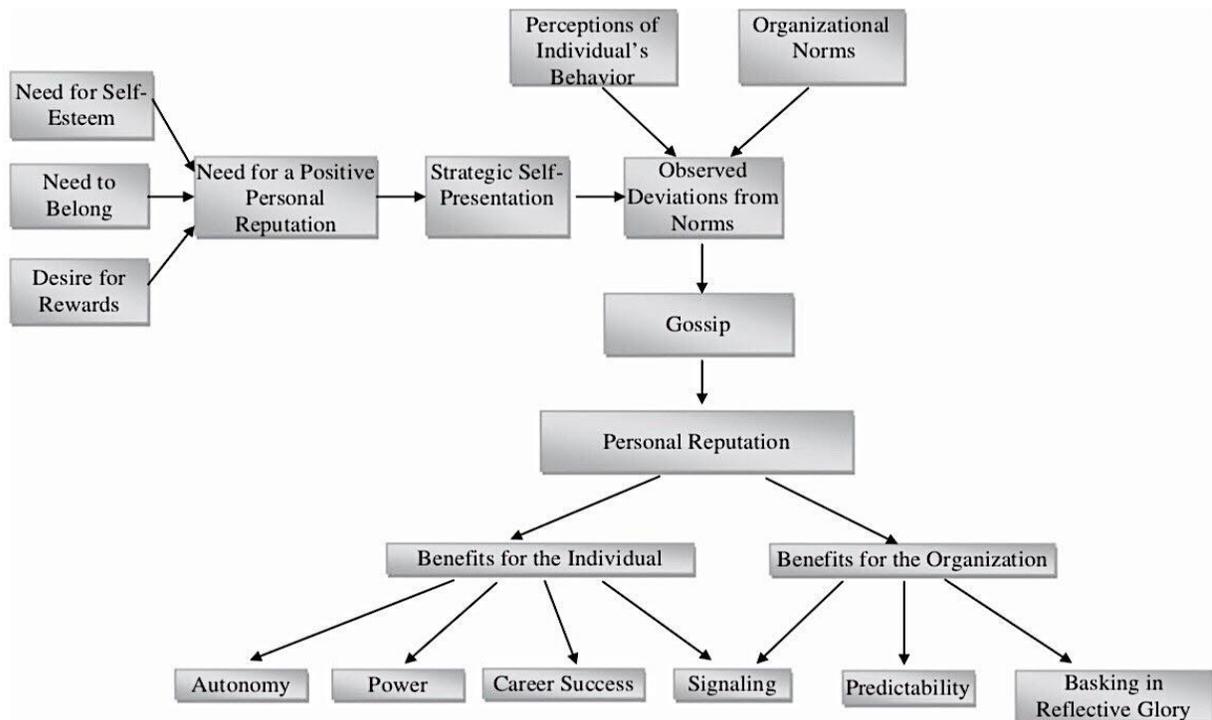
### Research on Personal Reputation

Personal reputation is described as a formation of perceptual identity as a result of the collective perceptions of others. It is claimed as a contemplation of the complex combination of demonstration of behavior, intention of images, and dominant personal characteristics and accomplishments presented over some duration of time (Furner & Zinko, 2017; Gorbatov, et. al., 2018; Pihl, 2013; Zinko, et. al., 2012; Zinko & Rubin, 2015).

Development of individuals' reputations can occur for many things in daily life. In fact, personal reputation is related to social and organizational life. Meanwhile, at the workplace, reputations obviously concentrate on issues regarding individuals' ability to perform their jobs efficiently, to be helpful and cooperative respecting others. Simultaneously, individuals will observe feedback about their own actions in conjunction with the feedback of others (Furner & Zinko, 2017). Furthermore, Ekpe, et. al., (2016 and 2015) argued that the importance of entrepreneurial skills in improving self-reputation. Baninajarian and Abdullah (2009) conceptualized the model of group effectiveness for competent facilitators with emphasis on team's communication skills. Furthermore, conceptualizing health literacy is vital for individual to enhance Asian personal value (Putri et. al., 2020).

There are individuals purposely creating negative reputations for themselves as mentioned by some researchers (Harvey, et. al., 2007; Zinko, et. al., 2016). However, the development of a positive personal reputation especially for new employees in the organization is crucial (Foste & Botero, 2012). Likewise, most researchers found that individuals seek to build up a positive image of themselves in the place they are working with (Baumeister, 1982; Cremer & Sedikides, 2008; Cremer & Tyler, 2005; Emelo, 2012; Gerald R Ferris et. al., 2007; Foste & Botero, 2012; Furner & Zinko, 2017; Gorbatov et. al., 2018; Zinko et al., 2012; Zinko, et. al., 2010; Zinko, et. al., 2017; Zinko, et. al., 2016; Zinko & Rubin, 2015).

A recent review on personal reputation claimed that it is being used by individuals to satisfy their need for positive self-esteem in addition to secure their need to belong in organizations. Indeed, personal reputation authorizes individuals to receive rewards including power, autonomy, and career success. Zinko and Ruben (2015) present an interactionist model of personal reputation within organizations as shown in Figure 1.



**FIGURE 1.** An interactionist model of personal reputation within organizations (Zinko and Ruben, 2015)

## ANTECEDENTS OF PERSONAL REPUTATION

Current research argues that in order to build and sustain a personal reputation, we must consider three factors. They are needed for self-esteem, need to belong as well as the desire for rewards (Zinko & Rubin, 2015).

### Need for Self-Esteem

Self-esteem is described as a person's appraisal of personal value or self-worth. It indicates a degree of one's appreciation particularly on appearance, beliefs, and behaviors. Generally, self-esteem is more strongly influenced by perceptions of others' evaluations of oneself instead of one's ability or goodness. This is because individuals are inspired to prove people around them of this good image in conjunction with the ideal self-fulfillment (Leary & Baumeister, 2000). Thus, in order to fill a basic need for both self-fulfillment and self-esteem, the desire for a positive personal reputation exists. A study in Singapore suggests that the level of self-esteem shall be a ruling or a moderating effect on the performance of one's job. Individuals with high self-esteem or high-self evaluations are inspired to well-performed on their job. This is done to maintain cognitive consistency (Ferris & Brown, 2010).

In addition, Laurell (2013) carries out an online study of three professional bloggers from Sweden. The outcome shows that the characteristics of individual including self-esteem are associated with relatively personal reputation. The result claims a positive relationship between their self-esteem and personal reputation. Next, a study on 77 participants from London is conducted to see the relationship between the independent variable, self-esteem and the dependent variable, personal reputation. The result indicates that a positive reputation is aligned with high self-esteem (Cremer & Sedikides, 2008).

Recently, there is research conducted in Australia shows the same result whereby individuals employ personal reputations to secure their need for positive self-esteem in organizations (Zinko & Rubin, 2015). Consequently, it can be argued that a need for self-esteem is a major inspiration for individuals to build a positive reputation. Thus, we develop the first proposition as follows,

Proposition 1: Need for self-esteem has a positive significant effect on personal reputation

## **Need to Belong**

Apart from self-esteem, most of the therapists have acknowledged the individual's need to belong as an important aspect of a positive personal reputation. It is found in every human being regardless of cultures. However, there're still differences in terms of the strength and intensity of the need to belong in an individual. Plus, the way the ones expresses and satisfies his or her need to belong is also different (Baumeister & Leary, 1995; Gorbatov et. al., 2018). Despite the fact that the need to belong is somehow connected to the need for self-esteem, it is clearly a definite construct (Shamma, 2012). It is concerned that the personal reputation of individuals is established by the need to belong to a social group. Eventually, it improves interpersonal bonds within groups. Indeed, this factor also acts as a driver to create a positive position in the group. This is proven by a study conducted for 73 Dutch undergraduate students who volunteer to participate in the research. The result shows a positive relationship between their sense of belongings and personal reputation (Cremer & Tyler, 2005).

A study performs in Sweden aimed to examine the relationship between the need to belong and the personal reputation of an individual. Thus, a sample of three professional bloggers is chosen. They are from the advertising industry. The result shows the alignment between the need to belong and their personal reputation (Pihl, 2013). A research which is conducted in Florida aims to identify the independent variables, the antecedents of personal reputation within organizations. It involves 221 respondents from four different organizations. The result supports a positive relationship between the need to belong and personal reputation by Zinko and Rubin's (2015) study.

Currently, there is research conducted in Australia reports the same result where personal reputation is used by individuals to secure their sense of belongings in organizations (Zinko & Rubin, 2015). Hence, it may be claimed that a need to belong will absolutely drive individuals to build a reputation in a positive manner. Thus, we develop the second proposition as follows,

Proposition 2 The need to belong has a positive significant effect on personal reputation.

## **Desire for Rewards**

Besides the need for self-esteem and need to belong, the desire for rewards also plays an important role as an antecedent for a positive personal reputation. The reward is used by management or the organization to motivate the employees (Fareed, et. al., 2013). It is a major tool to check the performance of employees. The individuals' desire for rewards includes autonomy, power and career success. These three rewards are often interactively correlated to personal reputation. Autonomy is known as the freedom of an individual to manage his or her work (Humphrey, et. al., 2007). Theory indicates that if one has a powerful personal reputation in an organization, then his or her autonomy will increase drastically. Moreover, Aziz, et. al. (2015) stated that the importance of medical supports in leveraging personal reputation.

The desire for rewards also relates to career success which leads to personal reputation. As suggested by Ferris and Judge (1991), individuals with strong personal reputations will influence people around them easily. Furthermore, personal reputation has an influence on actual performance even when objective measures are employed. Additionally, in order to govern the measurement of career advancement including promotions, performance evaluations, compensation, and employee mobility, personal reputation has been theorized (Zinko & Rubin, 2015). Therefore, it can be claimed that individuals build a reputation with the intention to increase career success. Therefore, we develop the third proposition as follows,

Proposition 3: Desire for rewards has a positive significant effect on personal reputation.

## **Gossip and personal reputation**

In most organizations, we see employees like sharing personal and work information with their counterparts using social media such as Facebook and Instagram. Eventually, sharing personal information can be viewed as gossip in the workplace. Gossip is defined as hearsay or conversation that consists of unconfirmed factual statements (Michelson & Mouly, 2000). Gossip is always being associated with rumors. Gossip often focuses on personal issues in the context of privacy and intimacy. It is a common understanding that gossip always carries a negative connotation. Zinko et. al., (2017) asserts that gossip has contributed to the growth of personal reputation studies. Achieving a powerful personal reputation may develop individual career advancement. Thus, gossip may give an impact on individual career success. Thus, we develop hypotheses as follows,

Proposition 4a: Gossip will have a direct and negative effect on career success.

Proposition 4b: Gossip partially mediates the effects of personal reputation on career success.

### Legitimacy and personal reputation

Nowadays, companies face great challenges in gaining their competitive advantages with regards to improving their reputation and legitimacy. With an increase in the Internet of things, everyone can judge any company based on their own experience or any relevant information they may retrieve from the Internet. This argument relates to the importance of corporate social responsibility (Abdullah, et. al., 2017) and corporate reputation (Abdullah, 2009) to help us to make judgment and decision making.

Thus, legitimacy is vital for every company to survive in a highly competitive business environment. There are two perspectives of legitimacy, one is a resource dependence theory and a second perspective is a new institutional theory. Abdullah, et. al. (2017) assert that the importance of corporate engagement with community in practicing legitimacy. Based on the resource dependence theory, the organization is seen as an open system which means the organization transacts resources to its environment openly (Dowling & Pfeffer, 1975, Pfeffer & Salancik, 1978). Whilst, the new institutional theory focuses on how an organization meets the expectation of environments. Thus, legitimacy is positively associated with a reputation (Czinkota et. al., 2014). Thus, it is interesting to argue that how legitimacy may influence career success. Additionally, Laird, et. al., (2012), found that personal reputation gives an impact on career success. Therefore, we develop hypotheses as follows,

Proposition 5a: Legitimacy will have a direct and positive effect on career success.

Proposition 5b: Legitimacy partially mediates the effects of personal reputation on career success.

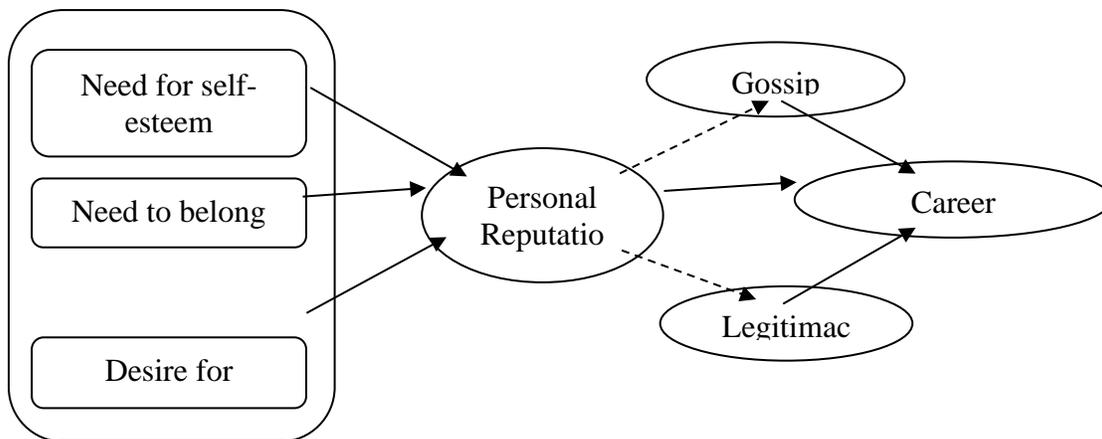


FIGURE 2: A Proposed Conceptual Model of Personal Reputation

Solid lines represent relationships hypothesized to be positive. Dashed lines represent relationships hypothesized to be partially mediated.

Having discussed the relationships between personal reputation career success rigorously, there are five testable hypotheses constructed to examine personal reputation, career success, gossip and legitimacy as depicted in Figure 2.

### THEORETICAL IMPLICATIONS

This study is a first attempt to examine how personal reputation influence career success, legitimacy, and gossip. This study advances the interactionist model of personal reputation within organizations and the theory of social identity and reputation. Undoubtedly, managing personal reputation is vital in enhancing individual credibility and professionalism. Many studies focused on the importance of corporate reputation. But this study fills a gap in reputation typology studies by empathizing on the antecedent of personal reputation.

Additionally, deriving from the resource dependence theory and new institutional theory, legitimacy plays a significant role in influencing personal reputation. It is essential to understand how to meet high expectations from stakeholders in the creation of personal reputation. Furthermore, pertaining to the gossip construct, it is vital to explore

the theoretical link between gossip and personal reputation. This construct contributes to the organizational identity that strengthening social network groups. Abdullah and Seman (2018) stress having a unique corporate identity is one of corporate strategies in gaining competitive advantage. It gives impactful to the development of personal reputation in organizational excellence. Championing the personal reputation of internal stakeholders may enhance their career advancement.

## CONCLUSION

Based on past researches, it is concluded that the need for self-esteem, need to belong and desire for rewards play vital roles to personal reputation. Thus, the aim of this study is to develop a proposed conceptual framework of personal reputation. Specifically, it is also to investigate the effect of the antecedents towards personal reputation in Malaysia since the previous studies cater mostly in other countries. Mediating variables such as legitimacy and gossip may influence personal reputation in improving individual career success. It is suggested that cultural diversity (Abdullah, 2010; Abdullah, 2007) can be moderating variables to advance the conceptual framework in the context of Asian corporate communication.

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