

## Developing Comfortable Cloth Face Masks: An Experiment with Four-Ply Cloth

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### ABSTRACT

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The public usage of disposable masks is indeed practical to reduce the spread of covid-19, but they generate unrecyclable waste. This research aims to develop a pattern of cloth masks comfortable enough for citizens to use in their any activity to minimize plastic waste of disposable masks by switching to cloth masks. The method of this research is research and development (R & D) adopting seven of the ten steps of Borg and Gall's model. Those seven steps include research and information collecting, planning, develop preliminary of product, preliminary field testing, main product revision, main field testing, and product revision. The data of this research are the quantitative data collected by distributing questionnaires to respondent users and the qualitative ones gained by holding interviews with the subjects in the main field testing. Subsequently, the techniques for data analysis are interactive model for qualitative data and the descriptive analysis for quantitative data. The findings show that after stages of revision and modification, cloth masks can offer users comfort that they need and seek. The development of the products is based definitely on users' complaints and suggestions on what part of cloth masks, be it the main part or the supporting one, causes them to experience discomfort in their indoor or outdoor activities. This research only focuses on the level of comfort users feel while speaking and breathing inside cloth masks. Therefore, future research needs to focus on other properties of cloth masks such as their absorption and their filtration efficiency after being washed.

## 1. INTRODUCTION

For almost two years of COVID-19 pandemic, people have to get accustomed to wearing face masks [1]. Both health-care workers and ordinary people have worn disposable face masks to limit the transmission of the virus while doing their daily activities [2]. Disposable face masks have been available in the market in variety of models and colors, which enables people to buy and wear the ones which cater for their tastes [3]. Disposable face masks, in addition to being sold at affordable prices, also save people's time and set them free from having to take care for those masks. According to reference [4], disposable face masks are practical and available everywhere, so that the market trend of face masks is more increasing during the pandemic than it was before, as they have become one of people's basic needs [5].

However, not all face masks available to the general public are comfortable to wear. Indonesian people generally tend to choose face masks less expensive and more practical to wear. Herein comfort and safety are not main consideration to them. More often than not, as results of such tendency, the face masks often slip down, so that those people often take them off. Or they wear them perforce; consequently, they feel uncomfortable in the workplace because they have to wear the masks for a long time or because the material of which the

masks were made causes discomfort to their face.

Previous research shows that the development of the models of face masks is based on the identification of the widely worn ones [6]. World Health Organization also recommended that face masks must be composed of two layers to give wearers some comfort while they are speaking and breathing and cause no pain when used [7].

On the one hand, the public usage of disposable masks to reduce the spread of COVID 19 is indeed practical as the users can directly throw the masks away and do not need to launder them [8]; on the other hand, such usage of the masks can pollute the environment because it generates unrecyclable waste [9]. Not only does mask waste threaten the environment [10], but it also poses a serious risk of transmitting COVID19 to garbagemen and those people exposed to the final dumps [11, 12], especially when the mask waste was worn by a patient who then carelessly threw it away without previously disinfecting it [13].

Meanwhile, previous studies focus only on the filtration rate of the number of layers of the masks produced [14] and there was no study researching patterns for comfortable face masks. In order to produce comfortable face masks as well as minimizing the waste of disposable masks, this research focuses on the development of a pattern for face masks comfortable enough for people to use in all their activities.

## 2. METHOD

### 2.1 Research design

This research and development adopted the model of Borg and Gall which consists of 10 steps of development [15]. However, to ease and speed up the process of designing the products, the researcher only adopted seven of the ten steps: (1) research and information collecting, (2) planning, (3) develop preliminary form of product, (4) preliminary field testing, (5) main product revision, (6) main field testing, and (7) operational product revision.

In the first step, the researcher analyzed models and patterns of soft face masks which people widely wear. Based on the analysis in this step, the researcher identified those models by ripping out their seam and then duplicating the models.

In the second step, the researcher planned research and development by formulating the purpose of the research, namely to develop a pattern for face masks comfortable to use in public activities. The researcher made an estimation of cost, labors, and time needed to complete this research.

The researcher designed the new pattern and model in which face masks would be produced in the third step. The development process was based on the result of the analysis of parts of face masks causing discomfort or pain. Besides, in this step, the researcher also identified facilities and infrastructure needed to design and produce the new cloth mask and stages of development as well as appointing personnels to be involved and defining their roles in this research.

The fourth step began with expert validation, which was followed by the researcher's making revision to face mask products on the basis of the result of validation process and then putting the products to the preliminary field testing. The preliminary field testing was held twice to assess the level comfort of the products in terms of their pattern and model – to know whether or not the products are comfortable for daily activities in workplaces.

The fifth step was to make revision to the products based on the result of the preliminary field testing. The revision process in this step focused on the shape of the mask and the material of which the mask is made. Whether or the mask slips down while the wearers are speaking, whether or not it is easy to turn wet, and whether or not it is comfortable to wear serve as the main indicators in this step.

The sixth step is to put the products to the main field testing. The field test in this step was held after the products were revised and modified in accordance with the result of the second preliminary field testing.

The last step was to make the final revision of the products, namely face masks. It was from this step that the finding of this research was written up.

### 2.2 Respondents

The product developed in this research faced three field tests: two preliminary field tests, and one main field test. The first preliminary test involved 6 respondents, while the second involved 10 respondents. Those respondents included lecturers and staff of a faculty of a private university. Meanwhile, the main field test involved 48 respondents, consisting of lecturers and staff of some faculties of the same private university as those in preliminary tests. The reasons that the researcher selected the respondents from lecturers and faculty staff of a university were (1) that some of them suffered

discomfort when wearing face masks, (2) that some of them had to take off their masks when speaking or the masks sagged when they were speaking (3) that some of them had difficulty breathing when wearing face masks, and (4) that they had to still come to the university despite the outbreak of COVID-19.

### 2.3 Interview guidance

The researchers used technique of interviews in the preliminary tests to collect preliminary data about the comfort of the face mask produced in a new pattern and design. In the main field test, meanwhile, the researcher gave the respondents questionnaires for data-collecting process.

To achieve the purpose of this study, the researcher held open-ended interviews to dig up more in-depth information. Open-ended interviews granted the respondents freedom to answer the questions and convey their impression about the face mask which they were wearing, without any pressure or external intervention. With the purpose of creating relaxed atmosphere for the respondents and achieving emotional intimacy with them, the researcher formulated a guideline for the interview beginning with casual conversations. Furthermore, to have those respondents' detailed answers, the researcher asked what, why and how questions, which were followed by probing questions to ensure the reliability of their answers.

In general, the researcher asked three types of questions. The first type of the questions was about what the wearers of the face masks feel when breathing. This type of questions took the forms of questions: "Does the face mask you are wearing cover your nostrils when you are inhaling or exhaling the air? Why? What are you feeling then?" and "When wearing a cloth mask, do you feel sweaty and hot when exhaling the air? Why? What are you feeling then?" The second type of questions was about what the wearers feel when speaking. The questions were "When you are speaking, is the mask you are wearing set in its position or not? Does it slip down? Why?", "Does the cloth mask you are wearing adhere to your mouth when you are speaking? What do you feel then?", "Does the cloth mask you are wearing make you have difficulty speaking? Why?", and "Can people you are speaking with hear your words clearly? Why?". Subsequently, the third type of questions was about the possible pain the wearer can suffer when wearing face masks. In this case, the researcher asked questions such as "Do you feel any pain in your cheek when wearing face masks? What do you feel in your cheek then?", "Does the face mask you are wearing irritate your ears? Why?", "Does the face masks you are wearing leave a red mark on your face when taken off?", "Does the ear loop of your mask cause any discomfort on your opaque region? Why? What do you feel then?", and "Which one do you prefer, the mask with ear straps/headbands made of rubber or textile ribbon?".

### 2.4 Questionnaire

The questionnaire was used in the main field test. In this field test, the researcher distributed it to 100 respondents consisting of lecturers and faculty staff; nevertheless, only 70 data could be used. Table 1 shows the outline of the questionnaire used in this research. The respondents were expected to choose one of the four answers: strongly disagree, disagree, agree, strongly agree. The questionnaire did not include the neutral answer for respondents to choose, which

compelled them to have definite answers.

**Table 1.** The outline of research questionnaire

Variables	Indicators	Description
The Comfort Level of Cloth Face Maks	Breathing Comfort	<ul style="list-style-type: none"> <li>The mask attaches to their nostrils when the wearers inhale the air.</li> <li>The wearers feel the heat and sweat tripping under the mask when exhaling the air.</li> </ul>
	Speaking Comfort	<ul style="list-style-type: none"> <li>The mask slips down or shifts up when the wearers are speaking</li> <li>The mask attaches to the wearers' mouth when they are speaking.</li> <li>The wearers have difficulty breathing when speaking.</li> <li>The voice of the wearers is not clearly heard when they are wearing a face mask.</li> </ul>
	Wearing Comfort	<ul style="list-style-type: none"> <li>The wearers feel a slight pain in their cheek when wearing cloth masks.</li> <li>The wearers feel a slight pain on their earlobes when wearing cloth masks</li> <li>The wearers feel any discomfort in a part of their face when wearing cloth masks.</li> <li>The wearers feel any discomfort in a part of their head when wearing cloth masks.</li> </ul>

**2.5 Validity and reliability**

Product validation was carried out by two experts: a fashion expert and a health expert. Both were appointed to be the validation team because each of them had more than 5 years of experience in their respective field, they were well-informed about the development of COVID-19 from the perspective of their respective academic background, and they were closely concerned with the prevention of COVID-19 transmission. Based on the publication ethics, the names of the validation team members were written in codes, namely Expert\_1 as health's expertise and Expert\_2 as fashion's expertise.

The validity of instruments in this research was assessed by three criteria: (1) the correlation between each item score and total score must result in a value ranging between 0.4-0.7 or  $\geq 0.4$  and  $p$  value  $< 0.05$ ; therefore, the item is deemed to be valid; (2) the result of factor loadings must have a value greater than or equal  $\geq 0.4$  and the value of communalities must be greater than  $\geq 0.2$ , meaning that the item is thought to be acceptable; and (3) Alpha value after eliminating items should be less than  $\leq$  the scale reliability value, which means that the item is considered valid. When the instrument items fit two or more criteria mentioned, those items will definitely not be eliminated; in contrast, on condition that only a single criterion is fulfilled, the items will be deleted. In this research, the validity value of the product was 0.894, meaning the product was considered to be valid. As for its reliability, after the assessment using Alpha Cronbach test the product was considered reliable, with reliability value of 0.906.

**2.6 Data collection**

Data collection through interviews was carried out in

separated places, where each of the respondents was doing their jobs. Each interview session with a respondent took two hours because before beginning the interview, the interviewer asked each of the respondents to wear the cloth mask produced for about 60 minutes. Meanwhile, data collection using questionnaire was submitted in the form of short message texts sent in group text messaging applications.

**2.7 Data analysis**

The data analysis in this research involved both qualitative analyses and descriptive-quantitative analyses, depending on the types of data gained by the researcher. The qualitative analysis was performed in the beginning of the research process, namely from the process of data reduction to the processes of generating codes and drawing conclusion. The descriptive analysis, meanwhile, was performed in calculating mean values and standard deviation.

**3. RESULTS AND DISCUSSION**

In this part is the review of the result of the preliminary and main field tests, which will be analyzed in detail in the following paragraphs.

Interviews and observation about the comfort testing of the four-ply cloth face masks were held in two preliminary field tests, the first of which involved 6 participants, the second ten participants (including 6 participants involved in the first experiment and another four participants). The preliminary field testing was performed twice as the researcher found that the products of face masks required major revisions, which prompted the researcher to conduct another field test in larger groups before putting the products to the main field tests. Subsequently, the main field testing was also performed twice, with each involving 48 and 70 participants respectively.

**3.1 The result of interviews and observation in the first preliminary field test**

The observation and interviews in the first preliminary field test with six lecturers and university staff dealt with three aspects of the performance of the four-ply cloth face masks, namely breathing comfort, speaking comfort, and wearing comfort (whether or not the materials used for the mask and its ear straps/headbands cause wearers any discomfort when wearing face masks). The participants in the first small-group field test were asked to wear face masks for 60 minutes while doing their activities. The following paragraph reports the result of the interviews about the breathing comfort of the four-ply cloth face masks.

The participant 1 said that the mask did not fill the nostrils during inhalation, but it made the nose blow humid air during exhalation, which caused a slight discomfort. Speaking about their wearing the fac mask for 60 minutes, participant 2 experienced uncomfortable breathing in the beginning by way of adaptation to it. After several minutes of wearing it, he/she began to breathe as he/she does normally. Participants 3 and 6 felt that the mask filled their nostrils when inhaling and the mask inflated when they were exhaling. Meanwhile, participants 4 and 5 said that they felt comfortable breathing in spite of wearing the mask for 60 minutes, which resulted from the fact that the front part of the mask was curved and kept a right distance from the nostrils, thereby causing the

mask to fix in its position during inhalation or exhalation instead of filling the nostrils. Meanwhile, those participants wearing glasses (participants 5 and 6) found their glasses fogging up when exhaling air.

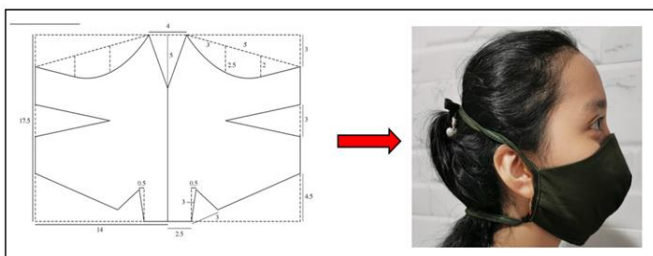
The observation made by the researcher on the breathing comfort of the participants when wearing the face mask for 60 minutes in the first preliminary field test of the four-ply cloth face masks showed that some participants felt a slight discomfort in their first five minutes of wearing the four-ply cloth face masks. They were caught frequently taking off their masks to breathe some fresh air for a while, although they began to adapt to the face masks after several minutes of wearing them. Likewise, those participants having on glasses were found removing their glasses or wagging their hands to prevent their glasses from fogging up by their own breath. Therefore, the four-ply cloth face masks still needed some improvement to allow the wearers breathe freely and comfortably. The uncomfortable breathing experienced by those participants resulted from the looseness of the upper part of the mask which stuck to the nose stem and the chin.

Subsequently, the interviews and observation also dealt with the speaking comfort of those participants when they wore cloth masks. The following paragraph reports the result of the interviews thereof.

The first time they tried to speak while they were putting on the four-ply cloth face masks, the participants wearing glasses felt uncomfortable, while the mask kept in position while speaking and doing their activities for 60 minutes. Meanwhile, the masks of the other participants (participants 1, 2, 3, and 4) also kept in position while they had been speaking for 60 minutes, but they felt uncomfortable because they felt air circulating through the mask cavity. However, participant 1 said that the mask did not adhere to the lips, but the upper part of the mask felt loose although the ear strap had been fastened tightly. On the contrary, participants 2 and 3 had different experiences in which they felt that the mask did not adhere to their lips, nor did the upper part of the mask feel loose. Participants 4, 5, and 6 also said that the mask did not adhere to their lips while they were speaking, but at the same time they felt the lower part of the mask (the chin) opened.

Through the observation, it was known that all the participants felt that the upper part of the mask (on the nose stem and the chin) was loose. Although the mask kept in position, they looked uncomfortable when trying to speak. During 60 minutes of wearing the mask, instead of fixing the mask in position, they seemed busy fastening the loose upper part of the mask while speaking.

The interviews and observation were subsequently directed to know whether or not the four-ply cloth face mask irritated the wearer, probably because of the materials used for the mask and the ear straps. The participants were asked to put on the four-ply cloth face masks with ear straps fastened to their head, as illustrated in Figure 1.



**Figure 1.** The cloth mask in the first pattern

Furthermore, the result of the interviews showed that male participants felt that the ear strap of the mask seemed not practical because it took some time for the wearer only to fasten the ear strap. Likewise, female participants not wearing veils also complained about the impracticality of the ear strap; meanwhile, those female participants in veils felt that the ear strap was so helpful that did have to change the style or model of their veil: they need only to fasten the strap to the back of their head. In this case, some participants requested the ear straps to be replaced with ear loops or the ones attached to the ear, not fastened to the head. Furthermore, when asked whether the ear strap caused physical harm to their face or head, those participants said that they suffered from no harm. The mask was comfortable enough to wear only that the ear strap was not practical and made the beginning of the mask wearing process fraught with technical difficulties.

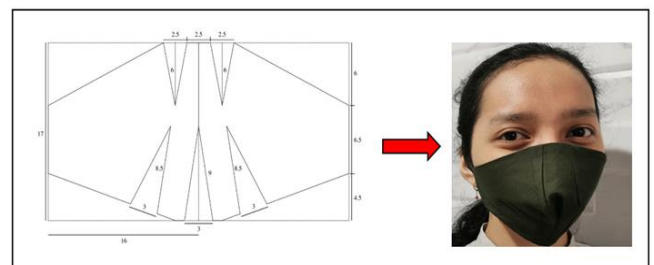
Based on the result of interviews and observation during the first preliminary field test, it was known that the cloth mask had failed to give the wearers great comfort, so that the pattern of the mask needed to be modified based on the participants' suggestions. Figure 1 shows the pattern from which the masks tested in the first preliminary field test were produced as well as its finished product.

### 3.2 The result of interviews and observation in the second preliminary field test

The second preliminary field test had the same focus as the previous one, namely the breathing, speaking, and wearing comforts the four-ply cloth mask offered to the participants. This second preliminary field test involved 10 participants, the six of whom had been involved in the first preliminary test, while the other four were new participants. The number of participants was added to have new suggestion and feedback about the four-ply cloth masks which had been modified based on the suggestion of those participants in the first field test.

The second preliminary field test was held a month after the first one because the researcher needed to do some preliminary experiments before the next field test. Besides, the second field test was performed at such interval to avoid possible data biases on account of the fact that all the participants in the first field test were involved in the second one.

The four-ply cloth mask put to the second field test had a different pattern than the one designed for the first field test (Figure 2 shows the new pattern for the cloth mask put to the second field test and the product designed from it). The pattern modification involved removing darts from the first pattern, namely by covering them and moving them into the upper and lower parts of the mask. Such alteration was expected to make the mask produced more comfortable to wear. In fact, the modification made the central part of the mask in an awkward shape and the mask was uncomfortable to put on, just as the finished mask shown in Figure 2.



**Figure 2.** The cloth mask in the second pattern

The result of the interviews held during the second preliminary field test stated that like the four-ply cloth mask in the first field test, the one put to the second test kept in position while the wearer was breathing, but unlike the previous mask, the newly-designed mask did not trap excess moisture while the wearer was exhaling (participant 1). The newly-designed mask was produced in a rather strange shape, but unlike the one in the first field test causing the wearer difficult breathing in the first minutes of wearing it, the new mask allowed the wearer to breathe comfortably (participant 2). Meanwhile, participants 3, 4, 5, and 6 said that they were able to breathe easily and comfortably while wearing the newly-designed cloth mask, and they did not feel the mask fill their nostrils during inhalation or exhalation. Some of those six participants complained about how strange the shape of the newly-designed mask was. In the meantime, the four new participants (participants 7, 8, 9, and 10) said that they felt comfortable to wear the newly-designed mask from the beginning they put on it although they had to perform their activities for 60 minutes. Those new participants also voiced their negative criticism about the strange shape of the mask.

From the observation made during the second field test, it was known that participants in glasses were not caught taking off their glasses while breathing. They did not find their glasses fogging up. Besides, no participant tried to remove their mask during their 60 minutes of activities, which was indicative of the fact that the mask in the second field test was comfortable to wear during their activities; however, those participants seemed to be disappointed at the unusual shape of the cloth mask.

As for the speaking comfort the newly-designed gave to the participants, the researcher noted the result of the interviews thereof as described in the following paragraph.

Most of the participants said the mask in the second field test stuck to their lips while they were speaking, which was uncomfortable. The six participants involved in the first field test said that in general the mask in the first field test gave them more speaking comfort than the new one. The four new participants, on the other hand, detailed when the mask stuck to the lips, namely when they had to open their mouth when

speaking, and not the other way around; participant 9 felt the mask sticking to his/her lips while he/she is speaking fast and breathing, which made the mask look to inflate and deflate in keeping with lip movements. Meanwhile, participant 10 said that the mask stuck to his/her lips every time he/she was speaking.

Based on the researcher's observation, the participants, asked to wear the mask for 60 minutes in the second field test, were known to pull the front part of the mask while they were speaking. Some participants kept holding the front of the mask to maintain it in position. This suggested that unlike the one used in the previous field test, the cloth mask used in the second test failed to give the speaking comfort to the wearers.

The last aspect to be taken into consideration in wearing cloth masks is whether or not they inflict physical harm to the wearer's face and head parts. Based on the result of the interviews about this aspect, the cloth mask in the second test, using ear straps like the ones in the mask in the first test, caused no harm to the face of the head parts of the wearers. However, the males of the new participants considered the ear straps to be impractical and difficult to fasten, while the females of those participants had no complaints about the ear straps in spite of their preference for more practical designs for the ear strap which will make the cloth mask more comfortable to wear.

Therefore, based on the second preliminary field test, it can be concluded that despite any modification from the one in the first field test, the cloth mask in this second field test needed to be remodified in accordance with the aforementioned results of the interviews and observation.

### 3.3 The result of the main field test

In this research, the main field test was performed twice as the four-ply cloth mask in the first main field test needed some major revision for greater comfort. Table 2 shows the answers to the questionnaire given by the participants in the main field tests. The first main field test involved 48 participants, while the second one involved 70 participants.

**Table 2.** The result of the main field test of the four-ply cloth mask

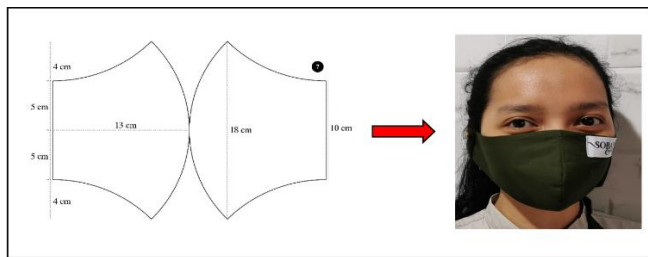
Indicators and Questions	The Answers to the Questionnaire							
	The First Test (%)				The Second Test (%)			
	SD	D	A	SA	SD	D	A	SA
<b>Breathing comfort</b>								
• Does the four-ply cloth face mask fill nostrils during inhalation or exhalation?	43.75	10.4	43.75	2.1	64	30	4	2
• Does the four-ply cloth face mask cause the wearers to breathe humid air when they are exhaling air?	64.6	22.9	12.5	0	52.9	31.4	15.7	0
<b>Speaking comfort</b>								
• Does the four-ply cloth face mask set in position or slip down while the wearers are speaking?	52.1	25	22.9	0%	44%	44%	10%	2%
• Does the four-ply cloth face mask adhere to the lips while the wearers are speaking?	64.6	25	4 8.3	2.1	42.9	35.7	17.1	4.3
• Can people you are speaking with hear your words clearly while you are wearing the cloth face mask?	54.2	33.3	10.4	2.1	25.5	58.5	14	2
<b>Wearing comfort</b>								
• Does the four-ply cloth face mask inflict physical harm to the wearer's face?	72.9	22.9	4.2	0	60	37.2	2.8	0
• Does the four-ply cloth face mask inflict physical harm to the wearer's ears?	68.75	18.75	10.4	2.1	61	37	2	0
• Does the four-ply cloth face mask inflict physical harm to the wearer's head parts?	45.75	31.25	20.9	2.1	55.7	25.7	12.9	5.7
• Does the four-ply cloth face mask inflict physical harm to the wearer's nose stem?	64.6	22.9	12.5	0	54.3	38.6	7.1	0

Notes: SD= strongly disagree; D= disagree; A= agree; SA= strongly agree



### 3.3.1 The result of the first main field test

Based on Table 2 the main field test was performed twice as the four-ply cloth mask in the first main field test needed some major revision for greater comfort. The first main field test involved 48 participants, all of whom were lecturers and staff of an Indonesian university who still provided services for students in a limited number despite the pandemic of COVID-19. The first main field test introduced the third pattern for the cloth mask. The third pattern for the mask was actually the refined version of the second pattern. To draw this new pattern, the researcher modified the design of the second cloth mask by removing all darts from it and made a slight alteration to its shape. As shown in Figure 3, the new cloth mask seemed to fit the wearer's face, thus being more comfortable than the one in previous tests.



**Figure 3.** The third pattern for the cloth mask

The first main field test implemented the same procedures as the previous test, under which each of the 48 participants was given a cloth mask, which was the refined version of the one put to the second preliminary field test. Those participants were asked to wear the mask for 60 minutes and then to fill out the online form whose web links had been sent to them. The questionnaire in the online form contained 15 questions, the first three of which dealt with the participant's identity (names and occupations). The next 12 questions were about the level of comfort the wearer of the mask had. These questions were focused on three aspects: breathing comfort, speaking comfort, and wearing comfort. The result of the first main field test can be seen in Table 2.

Based on Table 2, 21 participants agreed that the mask filled their nostrils while they were breathing, while another 21 participants strongly disagreed with such statement. 5 participants disagreed that the mask filled their nostrils while they were breathing, and 1 participant strongly agreed that the mask filled the nostrils.

Subsequently, Table 2 also shows participants' answers to the questions about their breathing comfort of the four-ply cloth mask when the wearers are exhaling. 31 participants strongly disagreed with the statement that the air in the mask was humid, meaning that they did not breathe warm air when exhaling; likewise, another 11 participants disagreed with the statement, which meant that they did not feel sweaty and hot when exhaling air. In contrast, the remaining 6 participants felt sweaty and hot while they were exhaling. From the questionnaire, it was known that the four-ply cloth mask needed a change in its materials and layers to prevent the mask from filling the nostrils.

As for the speaking comfort of the cloth mask, Table 2 presents three indicators concerning speaking comfort: whether or not the mask set in position while the wearer was speaking, whether or not the mask adhered to the lips while the wearer was speaking, and whether or not the wearer's words were clearly understood by the person he/she was speaking with.

25 participants strongly disagreed with a statement that the mask slipped down while the wearer was speaking. This meant that the mask kept in position (on the nose stem) and did not slip down. Another 12 participants had almost the same opinion, meaning that the mask remained on the nose stem. On the contrary, the other 11 participants agreed with such statement that the mask did not set in its correct position while the wearer was speaking.

Asked about whether the mask adhered to the lips while the wearer was speaking, the majority of the participants said that the mask did not adhere to their lips. It was known from Table 2 that 31 participants strongly disagreed, and another 12 participants disagreed with the statement that the mask adhered to their lips while they were speaking. The other five participants, on the other hand, felt the mask adhering to their lips while speaking. Meanwhile, as for the clearness of their words while wearing cloth masks, 26 participants strongly disagreed and 16 disagreed with the statement that the cloth mask they were wearing made their words barely understood by the people to whom those participants were talking. This meant that most participants admitted that their words were able to be clearly heard and understood despite wearing the cloth mask.

The last aspect considered in this field test dealt with the wearing comfort, namely the possibility that the cloth mask would cause any harm to the wearers' face, ears, or head parts. Based on the result of the first main field test, shown in Table 2, there were four indicators for this aspect, which referred to any body part of the wearer potentially getting harmed by the cloth mask: the face, the ears, the head, and the nose stem.

The data on the first indicator showed that on average the participants strongly disagreed (35 participants) and disagreed (11 participants) with the statement that the cloth mask caused harm to their face. In other words, most of the participants admitted that while they are wearing the cloth mask did not harm their face. Similarly, the data on the second indicator showed that majority of the participants strongly disagreed (33 participants) with the statement that the cloth mask irritated their ears, and another 9 participants disagreed with such statement. This meant that they felt no harm on their ears while wearing the cloth mask. Nevertheless, the remaining 6 participants felt that the cloth mask irritated their ears while they were wearing it. Subsequently, the data on the third indicator showed that the majority of the participants felt no harm on their head while they were wearing the cloth mask. Based on Table 2, 22 participants strongly disagreed with the statement that the cloth mask caused harm to the participants' head parts, and another 12 participants disagreed with that statement. Meanwhile, as for the last indicator for the wearing comfort, the data showed that 31 participants strongly disagreed and another 11 participants disagreed that the cloth mask irritated their nose stem, which meant that the cloth mask did not cause harm to the wearers' nose stem. On the contrary, as many as 6 participants admitted that they felt harmed on their nose stem while wearing the cloth mask.

In general, the first main field test suggested the need for more modification and improvement of the four-ply cloth face mask. Accordingly, the researcher made a modification based on the suggestion received from the test before putting the modified version to another main field test involving more participants. The next main field test would involve new participants with the academic background in health education in addition to those participants involved in the first main field test.

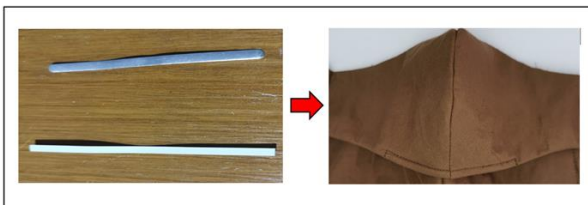
### 3.3.2 The result of the second main field test

This test involved 70 participants, consisting of lecturers, administrative staff of the university, doctors, and nurses. Their involvement was strictly necessary for constructive feedback on the four-ply cloth mask in this field test. The lecturers and administrative staff involved in this field test had actually been involved in the previous field test because the researcher hoped to notice the difference between the third cloth mask in the first main field test and the fourth cloth mask in the second main field test from the perspective of the same participants. Meanwhile, 22 new participants were involved purely for feedback on the fourth cloth mask. This second main field test also used questionnaire distributed in the online form easily accessed and filled out by participants. Figure 4 shows the fourth pattern for the cloth mask put to the second main field test. The fourth pattern was actually the remodified version of the third pattern for the cloth mask. Seemingly, the fourth pattern looked longer and slightly curved in the upper part. Such modification was made to fit the anatomy of human faces which are convex in the chin and oval in the nose. Therefore, the researcher designed this fourth pattern for the cloth mask in accordance with the structure of human faces as suggested in the first main field test.

What follows presents the data of the second main field test gained from questionnaire. The following paragraph will show the data in detail.

The first question in the questionnaire (See Table 2) dealt with the possibility of the cloth mask to fill the nostrils while the wearer is inhaling air. The result of the first questionnaire question distributed to 70 participants showed that 64% of the participants (45 participants) strongly disagreed with the statement that the cloth mask filled the nostrils when the wearer was inhaling. Additionally, 30% of the participants (21 participants) disagreed with such statement. On the contrary, the remaining 6% of the participants (4 participants) agreed with the statement that the cloth mask filled the nostrils while the wearer was inhaling air.

The second question in the questionnaire dealt with humid air the wearer would potentially breathe while wearing the cloth mask. Based on Table 2 showing the response of the participants to the statement that the wearer of the fourth cloth mask would feel sweaty and hot when exhaling, 53% of the participants (37 participants) strongly disagreed with the statement; 31% of the participants (22 participants) disagreed with the statement; 16% of the participants (11 participants) agreed with the statement.



**Figure 4.** The position of bone nose on the cloth mask

Subsequently, Table 2 also presents the data gained in the second main field test on the speaking comfort the participants had when they were asked to wear the fourth cloth mask. Like the data in the first main field test, that of the second main field test focused on 3 key indicators for the speaking comfort: whether the cloth mask keeps in position, whether the cloth mask adheres to the lips, and whether the words of the wearer are clearly understood. On average, most participants said that

the fourth cloth mask set in position and did not slip down, it did not adhere to the wearers' lips, and the people the wearers were talking to were able to understand their words clearly. In designing the fourth cloth mask, the researcher used supporting materials like soft metal (bone nose as shown in Figure 4) inserted in the inner layer of the cloth mask. The soft metal was used to fix the mask in position. This showed that the fourth cloth mask was comfortable enough to wear.

Another data shown in Table 2 is the participants' responses to the questions in the questionnaire on the possibility of the cloth mask to cause any harm to the wearers' body parts. On average, participants stated that the fourth cloth mask did not cause any harm to their face, ears, head parts, nor nose stem. This can be seen in the indicator of ear straps of the fourth cloth mask as shown in Figure 5.



**Figure 5.** The fourth cloth mask

As clearly shown in Figure 5, the fourth cloth mask had ear straps different from those of the previous cloth masks (from the first to the third cloth masks). In the fourth cloth mask, the ear strap was draped over the head or the back of the neck and fastened by tightening up a fastening tool called stopper. The use of the stopper is to ease the process of wearing the cloth mask by freeing the wearer from tying the ribbon or rope of the mask, which makes the process simpler.

Based on the aforementioned data, it was clear that the fourth cloth mask which was the refined and modified version of the previous cloth masks (from the first to the third cloth masks) managed to give the wearers much greater comfort. The researcher made major modifications by considering complaints and suggestions of the participants about some parts of the cloth mask they considered to need improvement for greater comfort [16]. Modified masks are personal protective equipment [6] which prevents the transmission of novel virus infection [17]. In the end, this research gave a n interesting finding: a cloth mask of high quality [18].

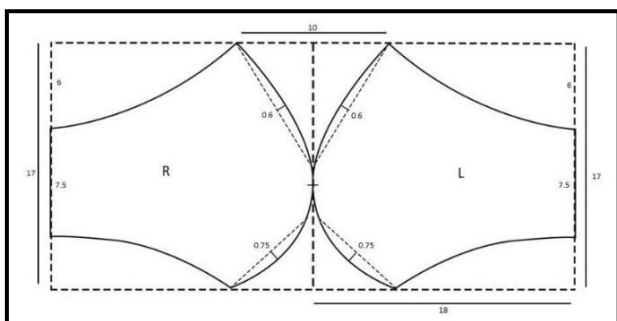
### 3.4 The recommendation on the new pattern for cloth masks

Finally, researchers offered a new pattern designed for cloth masks, as shown in Figure 6. It shows a cloth mask pattern, the wearing comfort of which was assessed in this research. This pattern can fit any shape of the wearers' face, especially the part around the nose.

The mask pattern in Figure 6 is the one people can widely use. This pattern was designed for those people with either pointed or flat noses. The steps in making a cloth mask in the pattern are explained as follows.

- Draw a horizontal line 36 cm long from the point A to the point B.
- Mark vertical lines 17 cm long from the point A to the point C and from the point B to the point D.

- Draw a rectangle by joining the points A, B, C and D.
- Dot the point E with half the length of the line segment AB (the point E is the midpoint of the line segment AB) and make the point F with half the length of the line segment CD (the point F is the midpoint of the line segment CD).
- Draw dotted lines from the point E to the point F.
- The distance between the point E and the point E1 is the same as the distance between the point E and the point E2, namely 5cm. Similarly, the distance between the point F and the point F1 is the same as the distance between the point F and the point F2, namely 5cm + 0.5cm.
- Draw vertical lines from the point E1 to the point F1 and from the point E2 to the point F2.
- Dot the point G 6cm below the point A, and dot the point H 6 cm below the point B.
- Ensure that the length of the point G to the point G1 and the length of the point H to the point H1 are 7.5cm.
- Dot a point between the point G and the point G1 and between the point H the point H1 with the length of  $\frac{1}{2}$  of 7.5cm, and then draw a horizontal line with the same length.
- Draw a line from both the points E1 and E2 to the point J, and do so from both the points F1 and F2 to the point J. Subsequently, locate the midpoint of the line joining E1 and J, and dot a point 0.6cm above the midpoint of E2 and J.
- Locate the midpoint joining F1 and J as well as the midpoint of the line joining F2 and J; then, dot a new point 0.75cm above the midpoints. Afterwards, draw a curved line across the new point to join the points F1, J and E1. Do the same to join the points E2, J, and F2 as illustrated in Figure 6.
- Draw a line from the point G to the point E1 and a line from the point H to the point E2, locate the midpoints of those lines, and then dot a new point 0.5cm below the midpoints. Afterwards, draw a curved line across the new point as illustrated in Figure 6.
- Draw a line from the point G1 to the point F1 and a line from the point H1 to the point F2, locate the midpoints of those lines, and then dot a new point 0.5cm above the midpoints. Afterwards, draw a curved line across the new point as illustrated in Figure 6.



**Figure 6.** Cloth mask pattern

#### 4. CONCLUSIONS

This research recommends the best pattern for cloth masks which can give users some comfort while they are wearing

them. The comfort of the cloth masks lies in their basic excellent design which seamlessly fits human face structure, for they were made by taking into consideration the position of nasal bones, the comfort level of wearers while speaking, and the use of organic fabric material.

In addition, the face mask production also needs to consider some other supporting aspects like the shapes, position, and material of mask straps. Such consideration is taken to ensure that the mask is tightly fastened without the wearers' having to tighten it. This will bring them some comfort even though they have to wear the mask while performing their daily activities at the office or everywhere. The shape choices of mask straps will also make it easier and more simple for individuals to wear face masks.

Another supporting aspect to be taken into consideration is to distinguish cloth masks designed for men from those for women. Such differentiation can be made by using different coloration. For example, the masks for men are produced in fabrics blue in color, while those for women are in pink. It is important to note that such coloration should consider choosing colors which do not fade rapidly in order not to negatively affect the quality of the appearance of the cloth masks.

Another factor behind the comfort in wearing cloth masks is mask cases easy to carry everywhere. The design of the case will add such a touch of elegance to the cloth mask that ones will feel more confident to wear their mask.

Hopefully, qualitatively, the pattern and model of cloth masks recommended by this research can substantially increase public awareness of the importance of the wearing of cloth masks: they realize that wearing cloth masks is more comfortable and more practical and looks more elegant thanks to the stylish design of their cases. Additionally, quantitatively, the wearing of cloth masks will help reduce the amount of waste because cloth masks are made of such organic material that they are washable and reusable. Subsequently, by way of providing useful feedback to the findings of this research, future research should focus on the absorption of face masks, their filtration efficiency and their effect on wearers' psychological state.

#### REFERENCES

- [1] Taylor, S., Asmundson, G.J.G. (2021). Negative attitudes about facemasks during the COVID-19 pandemic: The dual importance of perceived ineffectiveness and psychological reactance. *PLOS ONE*, 16(2): e0246317. <https://doi.org/10.1371/JOURNAL.PONE.0246317>
- [2] Kimmelmeier, M., Jami, W.A. (2021). Mask wearing as cultural behavior: An investigation across 45 U.S. States during the COVID-19 pandemic. *Frontiers in Psychology*, 12: 2423. <https://doi.org/10.3389/fpsyg.2021.648692>
- [3] Chua, M.H., Cheng, W., Goh, S.S., Kong, J., Li, B., Lim, J.Y.C., Mao, L., Wang, S., Xue, K., Yang, L., Ye, E., Zhang, K., Cheong, W.C.D., Tan, B.H., Li, Z., Tan, B.H., Loh, X.J. (2020). Face masks in the new COVID-19 normal: Materials, testing, and perspectives. *Research*, 2020: 7286735. <https://doi.org/10.34133/2020/7286735>
- [4] Brooks, J.T., Butler, J.C. (2021). Effectiveness of mask wearing to control community spread of SARS-CoV-2. *JAMA*, 325(10): 998-999.



- <https://doi.org/10.1001/JAMA.2021.1505>
- [5] Martinelli, L., Kopilaš, V., Vidmar, M., Heavin, C., Machado, H., Todorović, Z., Buzas, N., Pot, M., Prainsack, B., Gajović, S. (2021). Face masks during the COVID-19 pandemic: A simple protection tool with many meanings. *Frontiers in Public Health*, 8: 947. <https://doi.org/10.3389/FPUBH.2020.606635/BIBTEX>
- [6] Clapp, P.W., Sickbert-Bennett, E.E., Samet, J.M., Berntsen, J., Zeman, K.L., Anderson, D.J., Weber, D.J., Bennett, W.D. (2021). Evaluation of cloth masks and modified procedure masks as personal protective equipment for the public during the COVID-19 pandemic. *JAMA Internal Medicine*, 181(4): 463-469. <https://doi.org/10.1001/jamainternmed.2020.8168>
- [7] World Health Organization. Mask use in the context of COVID-19: interim guidance. <https://apps.who.int/iris/handle/10665/3371991>, accessed on Dec. 1, 2020.
- [8] Rubio-Romero, J.C., Pardo-Ferreira, M., del C., Torrecilla-García, J.A., Calero-Castro, S. (2020). Disposable masks: Disinfection and sterilization for reuse, and non-certified manufacturing, in the face of shortages during the COVID-19 pandemic. *Safety Science*, 129: 104830. <https://doi.org/10.1016/J.SSCI.2020.104830>
- [9] Selvaranjan, K., Navaratnam, S., Rajeev, P., Ravintherakumaran, N. (2021). Environmental challenges induced by extensive use of face masks during COVID-19: A review and potential solutions. *Environmental Challenges*, 3: 100039. <https://doi.org/10.1016/J.ENVC.2021.100039>
- [10] Dharmaraj, S., Ashokkumar, V., Hariharan, S., Manibharathi, A., Show, P.L., Chong, C.T., Ngamcharussrivichai, C. (2021). The COVID-19 pandemic face mask waste: A blooming threat to the marine environment. *Chemosphere*, 272: 129601. <https://doi.org/10.1016/J.CHEMOSPHERE.2021.129601>
- [11] Sangkham, S. (2020). Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. *Case Studies in Chemical and Environmental Engineering*, 2: 100052. <https://doi.org/10.1016/J.CSCEE.2020.100052>
- [12] Gedik, O., Demirhan, A. (2021). Comparison of the effectiveness of deep learning methods for face mask detection. *Traitement du Signal*, 38(4): 947-953. <https://doi.org/10.18280/ts.380404>
- [13] Mejjad, N., Cherif, E.K., Rodero, A., Krawczyk, D.A., Kharraz, J. El, Moumen, A., Laqbaqbi, M., Fekri, A. (2021). Disposal behavior of used masks during the COVID-19 pandemic in the Moroccan Community: Potential environmental impact. *International Journal of Environmental Research and Public Health*, 18(8): 4382. <https://doi.org/10.3390/IJERPH18084382>
- [14] Bagheri, M.H., Khalaji, I., Azizi, A., Loibl, R.T., Basualdo, N., Manzo, S., Gorrepati, M.L., Mehendale, S., Mohr, C., Schiffres, S.N. (2021). Filtration efficiency, breathability, and reusability of improvised materials for face masks. *Aerosol Science and Technology*, 55(7): 817-827. <https://doi.org/10.1080/02786826.2021.1898537>
- [15] Borg, W.R., Gall, M.D., Gall, J.P. (1989). *Instructor's Manual. Educational Research: An Introduction*, Fifth Edition. Longman, London, Britania Raya.
- [16] Koh, E., Ambatipudi, M., Boone, D.L., Luehr, J.B., Blaise, A., Gonzalez, J., Sule, N., Mooney, D.J., He, E.M. (2022). Quantifying face mask comfort. *Journal of Occupational and Environmental Hygiene*, 19(1): 23-34. <https://doi.org/10.1080/00405000.2020.1805971>
- [17] Sharma, S.K., Mishra, M., Mudgal, S.K. (2020). Efficacy of cloth face mask in prevention of novel coronavirus infection transmission: A systematic review and meta-analysis. *Journal of Education and Health Promotion*, 9(192): 1-8. [https://doi.org/10.4103/jehp.jehp\\_533\\_20](https://doi.org/10.4103/jehp.jehp_533_20)
- [18] Bhattacharjee, S., Bahl, P., De Silva, C., Doolan, C., Chughtai, A.A., Heslop, D., MacIntyre, C.R. (2021). Experimental evidence for the optimal design of a high-performing cloth mask. *ACS Biomaterials Science & Engineering*, 7(6): 2791-2802. <https://doi.org/10.1021/acsbiomaterials.1c00368>