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Entrepreneurial Activity for Integrating Mathematics, Art, and Social Science into Society

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Abstract.
This article shows how entrepreneurial activity is used in a mathematical research product. The used methods are online and offline marketing activities where mathematical formulas are implemented to create visual images, both 2-dimensional and 3-dimensional, namely parametric curves mapped with complex functions and using algebraic surfaces. The results of these activities are motifs built into the form of souvenirs, ornaments, accessories, and batik motifs. Furthermore, entrepreneurial activities were carried out with students, and small business craftsmen collaborated. The main result of this activity is the integration of mathematics with social and humanities activities. This has implications for the development of science and collaboration in economic recovery. Additionally, this activity provides production opportunities and provides new insights for ordinary people that mathematics can be expressed in batik motifs, accessories, souvenirs, and various derivative products.

Keywords: entrepreneur; mathematics; parametric; algebraic surfaces

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1. Introduction

Research conducted at universities often has not had a significant direct impact on society. This happens because researchers at universities are generally only involved in the development of the used science in the research. On the other hand, the Indonesian government wants real down streaming between the carried out research and the direct benefits of research for the community. The government also expects the results of the research as part of campus entrepreneurship involving various partners, academics, and students(1). Especially in the field of mathematics, mathematics is usually only a

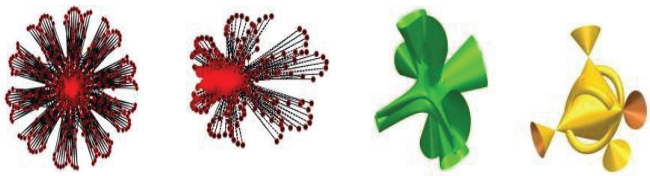
method of modeling and processing data that does not have a direct impact on its users. Meanwhile, the use of mathematics as an entrepreneurial activity has rarely been done in universities, some examples may be found in schools (2) (3)(4)(5). By paying attention to the government's target for research products that need to be released and the development of campus entrepreneurship, the state of the art of this research is conducting research related to the manufacture and development of products from mathematics to carry out campus entrepreneurship in this research.

The used mathematical concepts mostly are considered formulations that are limited to the obtained image display of various equations or functions. In particular, the used parametric equations have never been found to be domains of complex mapping by other researchers which shows the novelties of this research. Similarly, spherical coordinate equations are mostly used in classical mathematical functions in engineering applications(6). The spherical equation is used as one part of the preparation of the surfaces from the parametric equation. The original hypocycloid surface was simply an equation describing an equation of the curve obtained from the path of the small sphere around the larger sphere. In this study, researchers have made discoveries by utilizing equations to design various shapes of curves (2-dimensional) (7) and surfaces in 3-dimensional spaces(8). Similarly, algebraic equations have existed since the 17th century which is possible to visualize by the Surfer software creators in various forms. In this study, the equations are innovated into new equations to become new surfaces for batik motifs to integrate local culture with mathematics(9) and other product designs that provide campus entrepreneurial activities. Previous researchers in the field of mathematics had a great deal of knowledge in making geometric visualizations of recognized functions. Moreover, with the growth of computer technology, drawing mathematical shapes has become easier. One of the software is Surfer which is made by Imaginary researchers in Germany. The software is used only for showing by the creator of the software as a media exhibition. Because of the ease of the software to be used by students, students, and teachers, Surfer is used as a medium to become a supporting tool in making products with mathematical entities that can be used to conduct campus entrepreneurship which has never been done by mathematicians at universities or colleges. in Indonesia. Therefore, the purpose of this research is research that makes products with mathematical entities from parametric and algebraic surfaces to be material for campus entrepreneurship activities to be able to socialize research products and be able to market them to the public. This article shows some examples of the products and related entrepreneurial activities.

2. Method

2.1. Creating designs from mathematical formulas

From 2010-2015 research was carried out to form designs made of parametric curves where these curves become the domain for mapping complex functions. The obtained results are in the form of new curves that are considered attractive and these new shapes can be expressed as images on areas such as t-shirts, bags, and ornaments. Attractive requirements are very subjective depending on the user. However, some general properties can be considered so that the obtained images are considered attractive or have aesthetic value for consumers. Suppose the curve does not resemble the existing forms, the curve or the surface has a unique symmetry and can be formed on the selected media. This procedure needs some communication with product makers where problems may occur during the process. Additionally, making designs as motifs on products to be made needs to pay attention to several aspects such as whether the designs are possible on the desired media. Some examples will be shown where some formulas are not given much attention. Figure 1 illustrates designs from a complex mapping of hypocycloid curves that are not possible for batik motifs and 2 others are designs made from the software Surfer and the images are possible for batik motifs.



Flower hat (left) and Spider Cos (right): designs for 2-dimensional designs, not possible for batik motifs. Designs from hypocycloid curve mapped by complex function.

Designs are done by software Surfer; possible for batik motifs and ornaments.

Figure 1: Illustration for non-possible batik motifs (the first two from the left)and designs for possible batik motifs including ornaments, and accessories (Source: private collections)..

In 2016, Surfer software was recognized where it provides surfaces drawn easily when surface equations are written. This can be tested, by providing training to junior secondary school students at SMP Negeri IV Salatiga in 2017, and 200 students of the same level in Malaysia. Students can use this software to compose designs as basic motifs for batik to be made into motifs without having big difficulties. Figure 3 shows how the basic design from an algebraic surface and depicted into a stamped batik motif where the mathematical equation is shown.

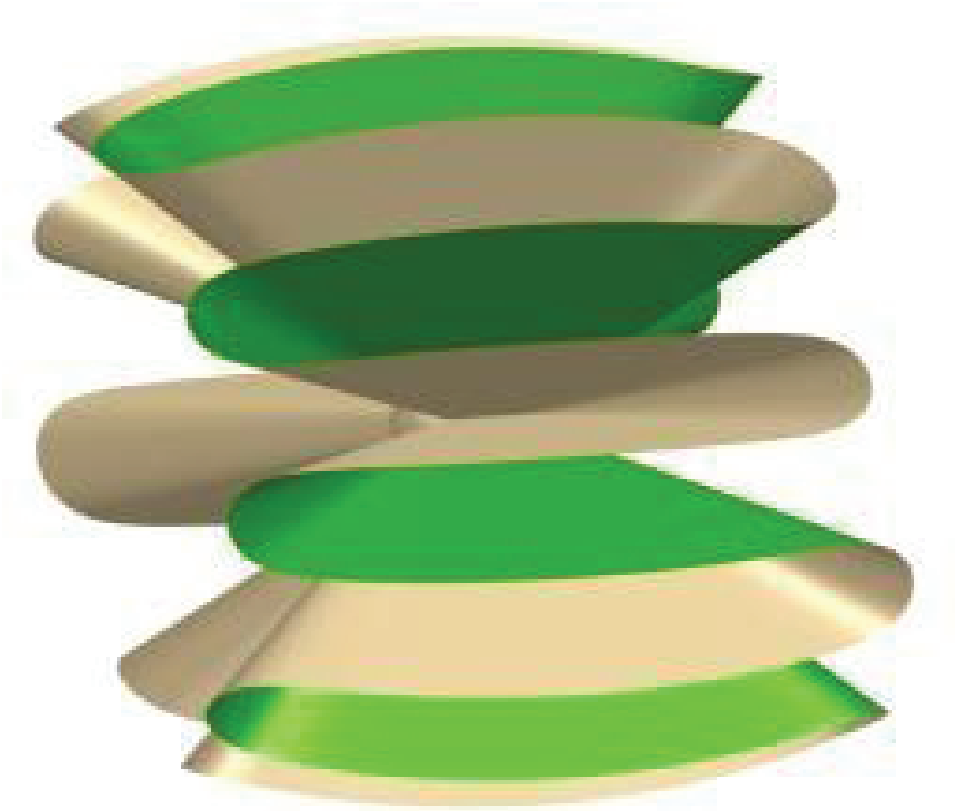


Figure 2: The mathematical formulation for the Parango-Int motif written in Surfer's scripts :(x∧9-36*x∧7*y∧2+126*x∧5*y∧4-84*x∧3*y∧6+9*x*y∧8+64*z∧9-9*x∧8+126*x∧6*y∧2-126*x∧2*y∧6+9*y∧8+27*x∧7-27*x∧5*y∧2-135*x∧3*y∧4-81*x*y∧6-144*z∧7-21*x∧6 225*x∧4*y∧2+45*x∧2*y∧4-39*y∧6-36*x∧5+72*x∧3*y∧2+108*x*y∧4+108*z∧5+54*x∧4+108*x∧2*y∧2+54*y∧4+9*x∧3-27*x*y∧2-30*z∧3-27*x∧2-27*y∧2+2.25*z+4.25)*(x∧2+y∧2+z∧2-5) = 0; zoom0.04x.

2.2. Products Supply and Development with small enterprises

With the obtained designs, there are various types of products that are classified into 2 major groups, namely BATIMA (Batik Innovation of Mathematics) and ODEMA (Ornament Decorative of Mathematics). As the name suggests, BATIMA consists of batik products consisting of written batiks, stamped batiks, and printed batiks. While ODEMA consists of souvenirs, accessories, and ornaments as well as several derivative products such as tote bags, glasses, t-shirts, key chains, pillowcases, bed sheets, and tablecloths. Accessories have been made of copper, silver in 2021, and gold in 2022.

The given examples here in Figure 4 are given to share the idea of the method of creating a design for a batik motif. One may combine several designs into new batik motifs.

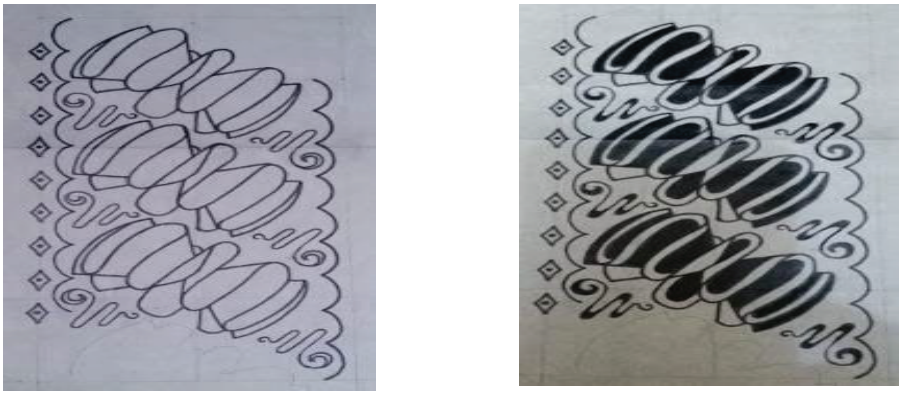


Figure 3: The initial state for designing the profile for a stamped of batik motif called Parango-Int..

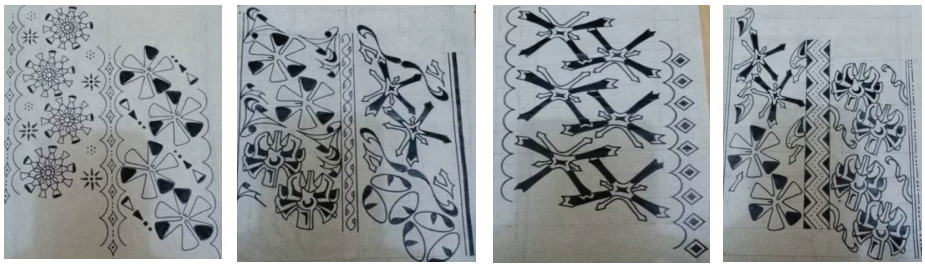


Figure 4: Several prototypes of batik motifs for batik stamps. (Source: private collections).

2.3. Social engagement with communities

To be able to introduce entrepreneurship with mathematics, it is necessary to engage with communities. The targeted communities are generally school students, teachers, and lecturers in training or seminar activities, as well as meetings with a batik community, and some entrepreneurs in the same business areas.

2.4. Promotion Skills for entrepreneurial

2.4.1. Digital Promotion

Promotional activities today are very important to reach the public. Moreover, the development of digital technology is rapidly increasing. Therefore, promotional activities through social media such as Instagram, YouTube, and Facebook are carried out. Not only for marketing purposes, but this activity is more aimed at socializing messages from BATIMA and ODEMA products, namely that there are products with the main identity of mathematics. This agrees with the idea of digital technology that it affects an entrepreneurial ecosystem's construction (10).

2.4.2. Join Competition

Activities to socialize products with unique products are also carried out by participating in competitions. This is done continuously so that the government and the public will also recognize more of the products being traded.

2.5. Managing Sustainability

The sustainability of a project needs to be considered so that business activities that have grown do not stop but can continue to be expanded becoming business activities that have a significant impact on business people. Activities to regulate sustainability include maintaining digital information, product flow in and out, and structuring gallery space so that it can be a good place to visit. In addition, how to maintain personnel in business activities also needs to be considered so that business processes can provide welfare for all involved sustainably.

3. Result and Discussion

3.1. The results of the activity of making designs from mathematical formulas

Many designs are then selected based on the type of used materials. For example, making a 2-dimensional curve design using the hypocycloid equation which is mapped with a complex function so that new curves can only be printed on 2-dimensional media. Several curves are printed on tote bags, glasses, and to-be designs of accessories products. Figure 5 are examples of designs and related products produced in 2015.

Figure 5: Examples of designs and products based on a hypocycloid parametric curve mapped with complex functions and expressed in the product of motifs on glasses, bags (left, center), and head accessories (right) produced in 2015.

As it is stated that the designs are formed from algebraic surfaces, then the surfaces can be expressed in 2-dimensional images with various image directions which then become motifs for glasses, batiks, souvenirs, and accessories. Some examples of manufactured products are shown. For example, the Parango-Int motif is one of the motifs that have a copyright. It is one of the motifs in 2022 that was created and explained in the research method. The motif is then stated on a copper stamp and can also be a printing batik motif as depicted in Figure 4. Similarly, we can do this activity by developing some motives into new ones which are not shown here.

An algebraic surface can also be a design for accessories. In 2021, silvers were the used material. We observed that these accessories need more treatment to maintain their quality. Silver after a year changes its color so that the silver accessories look bad. Therefore, in 2022, gold is used to create accessories in limited numbers. Its storage does not have an impact on the quality of the product if it is stored for a long time. Two sets of golden accessories are shown in Figure 5.

Figure 6: Production with stamped batik and printing with Parango-Int motif.

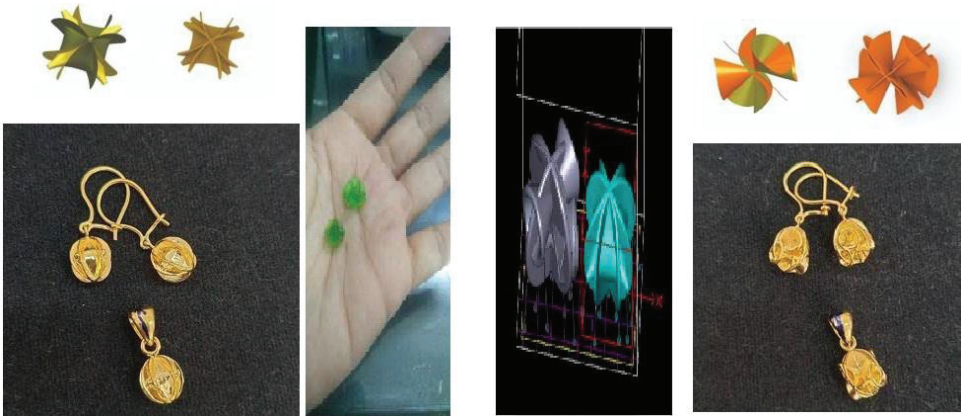


Figure 7: Golden math accessories made by the 3D printing machine where the designs are made from algebraic surfaces (shown above the products).

3.2. Results on Products Supply and Development with small enterprises

In the preparation of products, it is necessary to carry out manufacturers who have previously or often prepared these products or have related business units. For example, when making batik, the producer must be able to state the given motif to be a batik motif. Not all batik makers can understand the given ideas so when a capable and willing producer is found, these producers generally become subscribers to researchers. In these 3 years' activities, there are 4 batik makers involved as BATIMA producers. Similarly, there are 3 makers of accessories consisting of silver, copper, and gold. Other small enterprises are also related to packaging, promoting, and reproducing the products into other new products.

3.3. Results on social engagement with communities

As mentioned above that to disseminate the material, it is necessary to involve the community that can expand the knowledge that is the background of the made products. The community is targeted both internally and externally, locally, nationally, and internationally. The internal community is students, lecturers, and teaching staff, both structural and non-structural. In lecture activities, for example, students make designs to become products. Furthermore, this design is funded so that it becomes a product by students. For example, in 2015, students held an exhibition with products made by students and several small business units. This was done, for example, by using the product as a uniform in several units at the university. In 2017, students at the mathematics department in the university designed community service for students in Public Elementary School called SMP N 4 in Salatiga. Supported by an education foundation, an activity for innovating mathematics with students was then reported in the journal(11). Likewise, products in the form of souvenirs were traded at the university.

The external community can be done by down-streaming the product to the community. One of them is by bringing designs to the people of Dusun Sawit, Girirejo Village, Ngablak District, and Magelang Regency where mathematical designs were used for decoration using aqua bottles which are often found in the hamlet area. This was carried out in 2018. In October 2021, the activity was to socialize BATIMA with the Salatiga Batik Community in the context of Batik Day.

Internationally, this activity was started by presenting at the international conference at ICM, Korea in 2014. Similarly, in 2016, this activity was introduced to the Surfer creator

from Germany so it received funding to participate in international activities in Berlin in 2016. In December 2016, this activity was introduced at an international conference in Solo, and to be one of the keynote speakers on this topic. Another international community was in 2019, the training on designing batik motifs was delivered to students at the junior secondary level in Johor Baru, as well as students at UTM consisting of various faculties. In particular, training activities for making designs for mathematics education masters students at UTM in 2019. Several international conferences were also attended to become scientific socialization activities behind the products made.

3.4. Results on Promotion Skills to entrepreneurial

Promotional activities today are very important to reach the public. Moreover, the development of digital technology is increasingly rapid. Therefore, promotional activities through social media such as Instagram, YouTube, and Facebook are carried out. Not only for marketing purposes, but this activity is more aimed at socializing messages from BATIMA and ODEMA products, namely that there are products with the main identity of mathematics. Furthermore, mathematics nowadays is encouraged to drive entrepreneurship (3).

The development of a marketplace that is currently developing also encourages entrepreneurial activities on campus to be able to take advantage of digital media (12). By conducting an informal survey of the selected type of marketplace, it is determined that Shopee and Tokopedia are places for sales. Activities in 2020 began with marketing using Tokopedia and Shopee (https://shopee.co.id/garisma2020) as well as promoting activities on YouTube, Facebook, and the web. Some lists of products and prices are shown in Figure 6.

In addition to the direct promotion of manufactured products, promotions are also carried out on several mass media such as radio and TV. Likewise, researchers also become speakers or resource persons about the benefits of mathematics at local, national, and international levels.

3.5. Results of Join Competitions

Activities to socialize products with unique products are also carried out by participating in competitions. This is done continuously so that the government and the public will also know more about it. The competition that was initially followed was Krenova 2014, a competition at the Salatiga city level by bringing the name ODEMA and its products

to be contested. The results of the competition need to be continued at the Central Java provincial level in 2015. Likewise, BATIMA was also competed to be listed in the business innovation center (BIC) so BATIMA became one of the innovations in 2016. Participation in the competition was also carried out in 2018 at HARTEKNAS (Day of the National Technology in Indonesia) which was awarded 2nd place in non-photographer innovative product photography for a photo of one of the selected products.

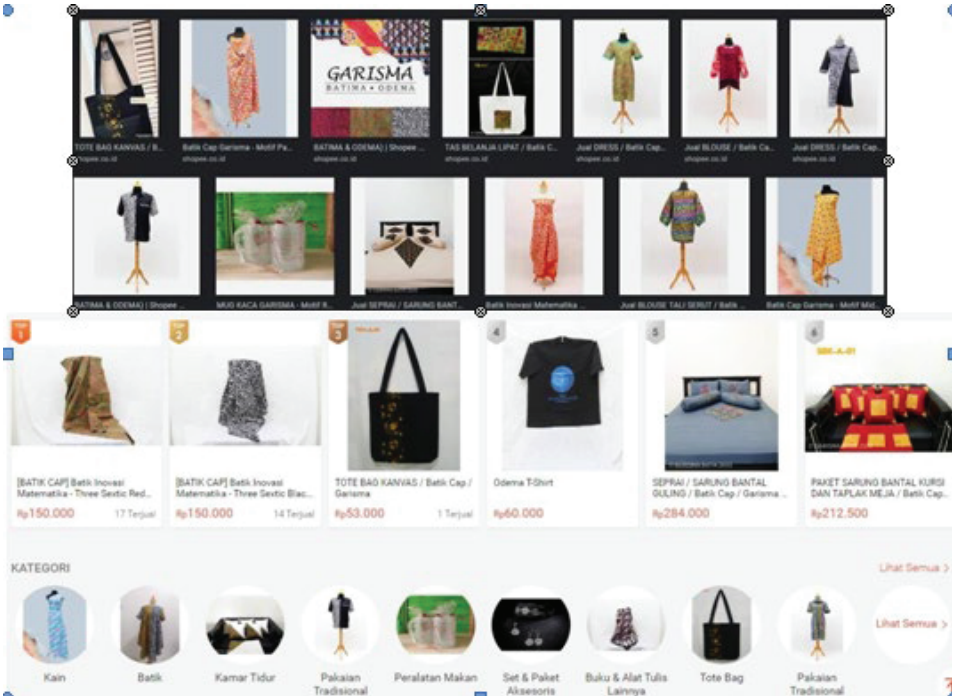


Figure 8: Examples of images collection in Shopee Garisma2020 (https://shopee.co.id/garisma2020).

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3.7. Results on Managing Sustainability

To maintain the sustainability of starting entrepreneurship in the university until to society, one has to put the effort into all aspects of running the business. Sustainability performance, sustainability opportunity, and sustainability commitment are required as minimum sustainabilities (13). By carrying out all the steps obtained above, in 2022 an off-campus store will be opened at the time of writing this article, this shop is in the process of being built. Products are re-registered both offline and digitally. Online sales activities are no longer only limited to CV GARISMA's account, but also use social media owned by partners in several places such as tourist attractions, and restaurants that have the same vision of product marketing, as well as updating the sales website which is currently also in the process of being manufactured. (garisma.net). Likewise, certain people are provided to maintain how the web is maintained.

3.8. Discussion

As stated in the introduction, the down-streaming of research related to research products from universities has not been significant to be traded, especially from mathematics. The results of the activities described above before 2020 were finally proposed to be campus entrepreneurial activities. With the existence of large enough funding, entrepreneurial activities have developed where the CV GARISMA as the related business unit which did not exist before 2020, was founded with more products in types and quantities. However, the pandemic in 2020-2021 greatly affects entrepreneurial activities to reach a wider community. Similarly, in 2021-2022 the developed entrepreneurial activity is still not significant. For this reason, in 2022 entrepreneurial activities will be carried out by doing more outside parties to be able to reach the community. Therefore, the number of marketing partners is improved.

At the beginning of campus entrepreneurship activities, we have a hypothesis that campus entrepreneurship in the field of mathematics is not significant on campus. After doing this for the last 3 years, the research has improved by having CV GARISMA as a university spin-off enterprise and a shop that is being prepared to maintain the sustainability of the business that is already running. Even though the marketing results of the products made in the last 3 years have not been seen significantly, the dissemination of knowledge that underlies the existence of the product has been carried out more massively than before the project funded by the Indonesian government (under the grant named PPUPIK). Moreover, the existence of this activity, which was carried

out during the pandemic, has provided resilience for small business actors related to the products made to provide an opportunity for production which was originally hampered due to the pandemic. Entrepreneurial on campus is rarely carried out among academics or mathematics users, though only a fewer researchers who have been there in developing mathematics are still limited to similar production. Instead, the exhibitions are delivered to introduce mathematics as more user-friendly. For example, fractal batik motifs are not used in other products. While in this activity, the motifs that become batik motifs can also be used for various products such as for designing accessories, ornaments, and 2-dimensional images on glasses, tote bags, or t-shirts.

Campus entrepreneurship efforts have only been initiated more seriously in the last 3 years whereas in the previous 10 years efforts have been made to introduce products on a limited scale (prototypes). Of course, the results of entrepreneurship are still not significant in the sense that they have not provided a large profit as expected in every business in general. However, this campus entrepreneurship was formed to put more emphasis on product socialization with a scientific background where unattractive mathematics becomes more attractive to the general public. For this purpose, the authors see that the product is increasingly recognized by the existence of various social media and mass media used for the popularization of mathematics by way of campus entrepreneurship accompanied by artistic aspects involving local culture (batik) and the use of software as a new technology for craftsmen to make motifs and designs. design. This is a strength and something new that has never been done by product partners. The weakness that emerged was that this activity was carried out during a pandemic, so product marketing was still limited.

The results of research in campus entrepreneurship are the downstream research that has been carried out for the last 10 years. This research develops the formulation of parametric equations and algebraic equations into images that can be used as product motifs. This includes new things where campus entrepreneurship activities are introduced which have never happened before on nearby campuses, even in Indonesia, there are still very few. To make it easier for readers to understand the results above, readers are advised to be able to visit you-tube which has been made for various results of research activities and downstream research above. The used keywords were BATIMA, ODEMA, SWCU, GARISMA, and the author's name. For down-streaming research, this research has not investigated how the community responds more massively and more objectively. For that, of course, a survey is needed to the community for the campus community and the community in general. Further research

can be done to provide further downstream research to the community. Among them is how marketing can have a significant impact.

From the explanation given above, the authors conclude that the down-streaming activities of research products in the field of mathematics on campus are new that have been done in the last 3 years where this is still very rarely done by a mathematician in the field of mathematics both in Indonesia and in the world. Similarly, the used methods in producing products that become objects in entrepreneurship are still new due to the innovation of mathematical formulations (parametric equations and algebraic surfaces) as well as making variations on these equations by using function derivatives, mapping complex functions, and many other mathematical operators or mappings to be new products for entrepreneurial activities indicating the novelty of this research.

4. Conclusion

This article shows the results of research in conducting campus entrepreneurial activities, especially for products made with designs from mathematics that have never been done at the university before 2020. This activity is also carried out to fulfill the government's goal to deliver research products to the public. This entrepreneurial activity is carried out where the preparation of designs and products has been carried out in the last 10 years, and socialization of the use of mathematics in products called BATIMA (Batik Innovation of Mathematics) and ODEMA (Ornament Decorative of Mathematics). The utilization of mathematics, especially related to parametric equations, complex functions, spherical equations, and algebraic surfaces is the most concerning in designing the curves and surfaces.

Because this entrepreneurship is carried out during the pandemic, product marketing has not had a significant impact on profits. However, the socialization aspect of the message conveyed by the product is more massive than in the past. Likewise, in 2022, there are also more marketing partners than in previous years to reach the community. This means that there exists progress on marketing partners and outreach. Even in 2022, digitization is reorganized so that digital marketing is updated. Likewise, there are additional stores that are in the process of being built.

Entrepreneurial activity is not only a downstream process as mentioned in the introduction. From the literature, it is known that entrepreneurial activities for students at universities provide competencies that have not been included in activities in learning classes(14)(15). The interaction between students and business actors at various levels has supported existing companies where students have new behaviors. Among them,

there is a readiness to enter the business world, understanding the achievements to be obtained better than those that are not included in entrepreneurship, and utilizing various digital technologies needed in entrepreneurial activities(16). Therefore, future research will focus on learning students' behavior in entrepreneurship activities related to the main subject.

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