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Improving the Competence of Students of SMK Roudlotul Mubtadiin in Making Furnaces and Kowi of Metal Casting

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Abstract

This community service activity aims to apply the results of research on making crucibles using evaporation boat waste as basic materials. The partner that will be the target of this activity is Roudlotul Mubtadiin Vocational School, this Vocational School has one major, namely mechanical engineering and in the PDTM (Basic Mechanical Engineering Works) subject there is metal casting competency. Crucibles made from waste evaporation boats can be used for non-ferrous metal casting processes which are more durable and suitable for vocational school students because they use easy casting techniques. The results that will be achieved in this activity are to produce outcomes in the form of increased understanding and skills of partners in metal casting, especially the manufacture of crucibles using waste evaporation boats and their use in non-ferrous metal casting. After this activity, partners are expected to be able to make crucibles from waste evaporation boats and use them for practical metal casting activities for Roudlotul Mubtadiin Vocational School students. The results that have been achieved are that a casting furnace and burner have been created for metal casting. The furnace that has been made has been tested and can melt aluminum. The conclusion of the community service activities is that students at Roudlotul Mubtadiin Vocational School have increased their competency regarding metal casting, especially in operating metal melting furnaces and making molds and the casting process. The increase in student competence is shown by an increase in the posttest score from the pretest score of 86%.

Keywords: *Casting; metal; evaporation boats; crucibles*

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A. INTRODUCTION

Situation Analysis

The definition of competence is the knowledge, skills, and abilities possessed by a person and with these abilities can perform actions in the cognitive, affective, and psychomotor domains well (Lapisa et al., 2017). One of the competencies in the Basic Mechanical Engineering Work (PDTM) subject is Metal Casting. Based on the Attachment to the Decree of Dikdasmen No. 464 / D.D5 / KR / 2018 concerning KI / KD SMK, there are Basic Competencies (KD) 3.10, namely

applying metal casting techniques and Basic Competencies (KD) 4.10, namely conducting metal casting. In its implementation, theory and practice are needed so that students understand and the objectives of the Basic Competencies (KD) can be achieved optimally.

The suboptimal learning of metal casting practices in SMK is due to the limited availability of equipment and materials. In carrying out metal casting practices, quite a lot of money is needed to provide tools and materials that are not cheap. Educators need to think of solutions to solve this problem so that learning metal casting practices in SMK can continue to run optimally. The optimal learning process is influenced by the use of relevant media. The benefits of learning media for teachers are to apply concepts/ideas and also motivate students to learn, while for students, learning media can be a bridge in thinking and acting. Therefore, teachers and students can be helped by the existence of learning media in achieving the competency goals that have been set (Karo-Karo S & Rohani, 2011).

One of the vocational schools that has PDTM subjects in its curriculum is SMK Roudlotul Mubtadiin. The PDTM subject at SMK Roudlotul Mubtadiin contains basic competencies about metal casting according to Attachment to the Decree of Dikdasmen No.464/D.D5/KR/2018 Basic Competency (KD) 3.10 is applying metal casting techniques and Basic Competency (KD) 4.10 is conducting metal casting. Casting is a manufacturing process that is widely used to produce components with various and complex shapes (Syrcos, 2003). The Basic Competencies (KD) should be for SMK Roudlotul Mubtadiin students to practice metal casting directly. The limited equipment and materials to practice metal casting are problems that must be solved immediately. The solution so that SMK Roudlotul Mubtadiin students can still practice metal casting without requiring a lot of costs and easy to implement is to choose the right metal casting technique.

The non-ferrous metal casting technique does not require a lot of costs and is easy to implement, namely metal casting. The advantages of non-ferrous metal casting are that it does not require high technical understanding and skills so that it can be applied in SMK. One type of non-ferrous metal casting is aluminum casting. Aluminum is a material with a low melting point so it is cost-effective because it can be recycled and the equipment needed to melt aluminum is relatively simple, namely using a crucible.

Figure 1. Graphite Crucible

Graphite crucibles have several weaknesses, one of which is that they can only withstand 10 times of fine melting and 5 times of coarse melting. Fine melting is melting that is carried out with a time gap, while coarse melting is melting that is carried out continuously without a time gap (Tamara et al., 2015). The crucible that has good quality with better durability than graphite crucibles (imported) is the imported crucible. However, when viewed from an economic perspective, imported crucibles are relatively expensive, so they are not suitable for use in the

metal casting process in vocational schools. The crucible that is suitable for use in the metal casting process in vocational schools is a crucible with an affordable price and has a quality of durability that is at least the same or better than imported crucibles.

Figure 2. Evaporation Boats

Evaporation boats are rectangular and trough-like (Vanbever et al., 2009). The community service team has conducted research on waste from evaporation boats. Waste from evaporation boats has characteristics that are resistant to high temperatures and are able to maintain heat in the desired area. These characteristics are in accordance with the properties that must be possessed by crucible materials. Crucibles made from evaporation boat waste have higher durability than graphite crucibles so that they can be used for a longer duration. This is what makes crucibles made from evaporation boat waste suitable for use in metal casting practices in vocational schools, especially at Roudlotul Mubtadiin Vocational School.

The partner in this community service is Roudlotul Mubtadiin Vocational School, especially for the Mechanical Engineering Department (Machining). Based on the situational analysis that has been carried out, there are problems in the implementation of metal casting activities, where metal casting has not been carried out optimally so that students do not understand and these competencies have not been achieved optimally.

Partner Problems

After conducting a situation analysis, it was discovered that the partner had a problem, namely the aspect of practical competence that had not been implemented, especially in metal casting practice activities. The low durability of the crucible causes the costs that must be prepared to carry out metal casting practices. The graphite (local) crucible can only withstand 10 times of fine melting and 5 times of coarse melting (Tamara et al., 2015). Meanwhile, the number of students at SMK Roudlotul Mubtadiin is very large, so they need a crucible that has a longer melting resistance at an affordable price (relatively cheap).

Partners in implementing this community service activity want to improve the practical competence of students, one of which is through metal casting practices. The crucible needed by partners is one that has a longer melting resistance at an affordable cost (relatively cheap).

Problem Solution

Based on the problems experienced by partners, namely how to improve the competence of metal casting practices, especially the price and melting resistance of the crucible which are still not as expected. There needs to be a crucible that has a long melting resistance at an affordable price (relatively cheap) so that it can be used repeatedly and the costs required in metal casting practice

activities are not too much. A crucible made from evaporation boat waste can be a solution to solve the problems experienced by partners.

A crucible made from evaporation boat waste can be used in metal casting practices. The price of a crucible made from evaporation boat waste that is affordable with a longer melting resistance can be a solution and applied at SMK Roudlotul Mubtadiin. A crucible made from evaporation boat waste is not obtained by buying it, but must be made by yourself. The process of making the crucible starts from crushing rectangular evaporation boat waste into several small pieces and then grinding it into powder. The powder will be used in making the crucible kitchen

Many things must be prepared by partners in the process of making a crucible kitchen from evaporation boat waste. This makes the community service team conduct training activities to make a crucible kitchen from evaporation boat waste. With this training, it is hoped that partners will be able to make their own crucible kitchen so that the problems faced by partners can be resolved and the metal casting practice process can be carried out optimally.

A. METHOD

Partner Issues

Partners in implementing this community service activity want to improve the practical competence of students, one of which is through metal casting practices. The crucible needed by partners, namely having a longer melting resistance at an affordable cost (relatively cheap).

Partner Participation

- Training

One way to change behavior and competence is by providing training (Saleh, 2010). The training aims to understand and master the competence of metal casting engineering activities. Before the training is carried out, basic theoretical knowledge about metal casting will be provided. This theoretical knowledge needs to be provided because theory is knowledge about something that is the starting point for practice (Sukardi et al., 2015). This training is intended for partners in carrying out community service activities. Training is the provision of skills, rules, concepts or behaviors systematically that result in increased performance in the work environment (Goldstein & Ford, 2002). The training is about the training material that will be given to partners in community service activities, namely the manufacture of crucibles from evaporation boat waste for metal casting practices, especially metals and the use of crucibles for metal casting. The training will be carried out in stages with partners by paying attention to the conditions of the partners so that the material can be conveyed optimally.

- Mentoring

Mentoring aims to control the process of community service activities. Mentoring is carried out by the service team to partners, starting from the process of preparing tools and materials, the process of making a crucible (kowi) kitchen, and the metal casting process and facilitating if there are obstacles during the process of community service activities. With this mentoring, it is hoped that community service activities carried out by partners can run smoothly, optimally and get maximum results.

Figure 3. Flowchart of Community Service Activities

- Evaluation

After community service was carried out at the partner's location, namely at Roudlotul Mubtadiin Vocational School, there were several evaluations, namely:

1. In order to obtain maximum results and deeper understanding for students at Roudlotul Mubtadiin Vocational School, it is necessary to add time to implement a series of community service activities at the vocational school.
2. To support the achievement of better competency in non-ferrous metal casting practices, it is necessary to improve and add tools in metal casting practices at the vocational school.
3. There needs to be ongoing and systematic cooperation between partners and related universities in community service activities, so that the competence of non-ferrous metal casting in the vocational school becomes more advanced and developed and closer ties are created.

- Roles and Duties

The team leader and crew in this community service activity have experience in community service activities. The team leader has conducted various studies on crucibles with evaporation boat waste. The team leader intends to apply the results of the research that has been carried out to the community, in this case SMK Roudlotul Mubtadiin, so that they can compete in the casting field, especially in terms of production by using crucible products made of evaporation boats which have a resistance of up to 30 times more durable castings compared to graphite kowi which can only last 10 castings. With the experience of the team leader, it is hoped that community service activities at SMK Roudlotul Mubtadiin can run smoothly. Team members are professionals in the field of mechanical engineering, especially in the fields of material science and casting. In addition, team members have been involved in various community service activities, both on campus and off campus. With the expertise possessed by the team, it is hoped that community service activities can run smoothly and can solve the problems faced by SMK Roudlotul Mubtadiin partners.

Table 1. Expertise of the implementing team

No	Name	Expertise / field / task
1	Rusiyanto, S.Pd., M.T.	Material/ Casting
2	Dr. Rahmat Doni Widodo, S.T., M.T.	Composite material
3	Rizki Setiadi, S.Pd., M.T.	Equipment design
4	Angga Septiyanto, S.Pd., M. T.	Energy conversion
5	Febri Budi Darsono, S.Pd., S.T., M.Pd.	Casting
6	Imam Sukoco, S.S.T.	Tool man
7	Muhammad Ashar Maulana	Handyman, documentation
8	Rahmad Pratomo	Handyman, documentation
9	Hewin Rafi Kurniawan	Handyman, documentation
10	Arif Munzaki, M.Pd.	Partner coordinator

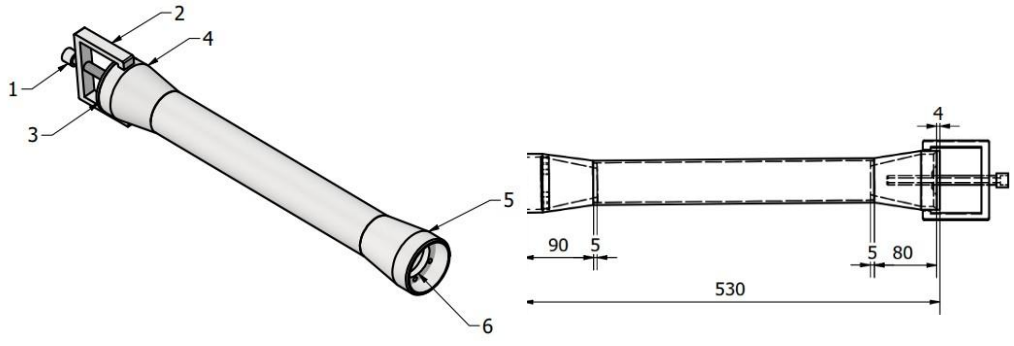
B. RESULT AND DISCUSSION

Implementation

Community service activities on improving the competence of SMK Roudlotul Mubtadiin students in metal casting have been carried out smoothly and without obstacles, with results in accordance with the plan. The following are the results of community service activities that have been achieved.

1. Burner Making

The initial activity of community service is to prepare all the equipment needed in the activity. One of the equipment needed is a burner or burner that functions as a heat source in casting. The burner in this community service activity was made by the community service team itself, as a follow-up to the research activities that had been carried out previously. The making of the burner begins with making a design first which is then continued with the manufacturing process. The burner design is shown in **Figure 4**.



ITEM NO	PART NAME	QTY
1	BAUD DAN NOZZLE	1
2	PENYANGGA BAUD	1
3	TUTUP BERNER	1
4	TIRUS ATAS BERNER	1
5	TIRUS BAWAH BERNER	1
6	SARINGAN BERNER	1

Figure 4. Metal Casting Burner Design.

Innovation in metal casting furnaces lies in the burner. The burner that is designed has better efficiency than burners on the market. With the efficiency of heat distribution in the furnace, the metal casting process becomes more effective. The finished burner will later be connected to a hose from an LPG cylinder. LPG is used as a fuel source, so a burner is needed that is able to channel heat well to the furnace. The burner that has been made through the fabrication process can be seen in **Figure 5**.

Figure 5. Metal casting burner fabrication results

2. Making a Melting Furnace

The next activity carried out by the community service team is making a furnace. The design of the furnace on the top is given a lid that can be lifted so that it is easy to insert or take kowi and metal into the furnace. The main material for making this furnace is refractory cement with a mixture of evaporation boat waste, so that it is resistant to high heat. At the bottom of the kitchen, a hole is added as a burner inlet, with the aim that the heat distributed can be more optimally distributed to the kowi. **Figure 6** shows a metal casting furnace that has been made by the community service team.

Figure 6. Metal Casting Furnace

Before being used for community service activities, the melting furnace was tested first. The test was carried out to determine whether the furnace could function properly and there were no leaks around it. The test of using the furnace and for metal casting is shown in **Figure 7**. The test was carried out by melting used aluminum metal. The results obtained from the burner and furnace can be used for metal casting practices.

Figure 7. Metal Casting Furnace Testing

3. Implementation of Community Service Activities

Community service activities were carried out at SMK Roudlotul Mubtadiin in Jepara Regency, all equipment and materials were brought to the service location. The implementation of the service began with the provision of theory to students, and ended with the implementation of practice on how to cast metal. The following are some of the results of community service activities at SMK Roudlotul Mubtadiin.

a. Providing theoretical material and pretest

Community service activities at SMK Roudlotul Mubtadiin were welcomed by the school. The activity began with a speech by the principal of the school, Mr. Arif Munzaki, M.Pd. In his speech, he said that metal casting is something new for SMK Roudlotul Mubtadiin students, so it is hoped that this activity can be applied by students as one of their final assignments as a graduation requirement. The next activity was the provision of brief material on how to make a furnace and kowi in casting. Before the explanation was given, the community service team gave a pretest to students to find out the initial abilities of students about metal casting, as shown in **Figure 8**.

Figure 8. Implementation of Pretest

After the students finished the pretest, the community service team provided material on the basic theory of metal casting. The material was delivered in a classical manner using a presentation display carried out in the theory room in the school workshop as shown in Figure 9. The community service team provided material that included equipment for metal casting, and several basic techniques

in metal casting, especially non-ferrous metals. The explanation was given as a prelude before students carried out direct practice to cast metal, so that students could know what to do in the implementation of the practice later.

Figure 9. Giving theory

b. Practice operating the tool

After the SMK Roudlutul Mubtadiin student partners were given the theory, it was continued with the application in practice. However, before carrying out the practice, partners need to be given an explanation of how to use the equipment used, including the burner and furnace. This is done so that SMK students or teachers when they are going to melt metal can operate it properly and correctly because when there is inappropriate use it can shorten the service life of the equipment. The explanation activity of metal casting equipment is shown in **Figure 10**.

Figure 10. Equipment description

The community service team provided knowledge on how to operate the furnace and also the burner that uses LPG as its fuel. Partners were given a direct example of how to operate the furnace starting from turning on the burner, adjusting the amount of air and fuel mixture on the burner and also on the LPG regulator. The community service team demonstrated how to turn on the burner along with its work safety, with the hope that there would be no work accidents when carrying out metal casting activities. **Figure 11** shows the community service team giving an example of turning on the burner.

Figure 11. Turning on the burner on the furnace

c. Conducting metal casting practice

The next community service activity was to practice metal casting using a kowi that had been made by the community service team using waste evaporation boats as the basic material. At the beginning of this activity, the community service team conducted a direct demonstration of the stages of the metal casting process, which began by inserting the metal to be melted into the kowi, which in this activity was used aluminum metal. After the metal was prepared, partners were given an example of operating the furnace by inserting the burner into the furnace hole at the bottom, as shown in **Figure 12**.

Figure 12. Furnace operation

The furnace operation process is intended to melt the prepared metal. To be able to carry out the casting process, the metal must be in liquid form so that it can be molded according to the shape of the mold. Melting aluminum requires a minimum temperature of 700ºC, so it takes a long time to produce liquid aluminum. While waiting for the aluminum to melt, the community service team trained students of SMK Roudlutul Mubtadiin on how to make casting molds from molding sand. This skill is only given as far as how to make sand molds and how to pour liquid metal into molds, as in **Figure 13**.

Figure 13. Making sand molds

The mold that has been made by the partner will be used to pour the molten aluminum metal. The molten aluminum metal is then taken at once with a kowi using the help of a special tool so that it is not exposed to direct heat. After being removed from the furnace, the molten aluminum is poured directly into the mold carefully so that it enters through the inlet and does not spill elsewhere. **Figure 14** shows the process of pouring molten aluminum metal into the mold.

Figure 14. Pouring metal into sand mold

After the molten aluminum is poured into the sand mold, the next step is to wait a while for the aluminum to harden and not stick to the sand. To be able to find out the results of the molten aluminum metal casting, the sand mold is dismantled. The sand mold is a type of non-permanent mold that can only be used once, and to see the results it must be dismantled, as shown in **Figure 15**.

Figure 15. Dismantling the mold

Based on several activities that have been carried out by the community service team, SMK Roudlotul Mubtadiin partners feel helped by the community service activities on metal casting. Students and teachers of SMK Roudlotul Mubtadiin gain new experiences in carrying out metal casting activities and learn the sequence in metal casting, especially aluminum metal with sand molds. The community service team also donated metal casting equipment, starting from 4 kowi, and a furnace package along with other equipment such as burners and LPG cylinders. This aims to enable SMK Roudlutul Mubtadiin partners to carry out metal casting practice activities independently. The handover of metal casting equipment was carried out symbolically by the community service team and also the principal of Roudlotul Mubtadiin as seen in **Figure 16**.

Figure 16. Handover of casting equipment

Discussion of Community Service Results

The success of community service activities in general has been good, starting from achieving the objectives of the service according to plan, as well as increasing student competence in practicing metal casting. The planned training activities can be carried out well, starting from the basic introduction of kowi and metal casting furnaces to practicing metal casting with sand molds. With the achievement of the planned training activities, the competence of SMK Roudlotul Mubtadiin students in performing metal casting can be even better. Where previously the partners had never had basic knowledge about metal casting and there had been no metal casting practice activities.

In order to find out the increase in competence of SMK Roudlotul Mubtadiin students, the community service team conducted a pretest before the training activities began and conducted a posttest after the training activities were completed. This aims to determine whether there is a change in student competence when given training by the community service team, especially in metal casting competence. The results of the pretest and posttest scores that have been carried out on 18 SMK Roudlotul Mubtadiin students are shown in **Table 2**.

Table 2. Pretest and posttest scores

No	Name	Score	
		Pre Test	*Post Test*
1	Respondent 1	30	50
2	Respondent 2	30	53
3	Respondent 3	30	47
4	Respondent 4	30	53
5	Respondent 5	33	50
6	Respondent 6	25	60
7	Respondent 7	33	58
8	Respondent 8	25	60
9	Respondent 9	30	57
10	Respondent 10	25	53
11	Respondent 11	25	60
12	Respondent 12	30	60
13	Respondent 13	30	60
14	Respondent 14	40	62
15	Respondent 15	30	53
16	Respondent 16	30	58

No	Name	Score	
		Pre Test	*Post Test*
17	Respondent 17	33	58
18	Respondent 18	30	50
	Average	**30**	**56**

Table 2 shows that the pretest and posttest scores of 18 students who participated in community service activities have changed. The posttest score increased when compared to the pretest score with an average pretest score of 30 while the average posttest score was 56 from 18 students who had filled in. The posttest score increased by 26, or around 86%. The diagram of the increase in pretest and posttest scores is shown in **Figure 17**.

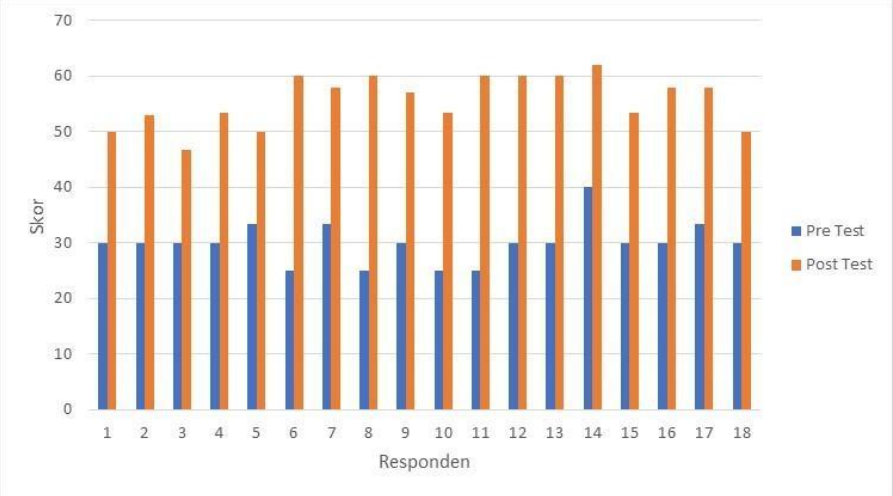


Figure 17. Pretest and posttest scores

Community service activities on making metal casting furnaces and kowi can be said to be effective in improving the competence of SMK Roudlotul Mubtadiin Jepara students. The increase is indicated by an increase in the average pretest and posttest scores of 86%, which is included in the high category. The percentage diagram of the increase in pretest and posttest scores is shown in **Figure 18**.

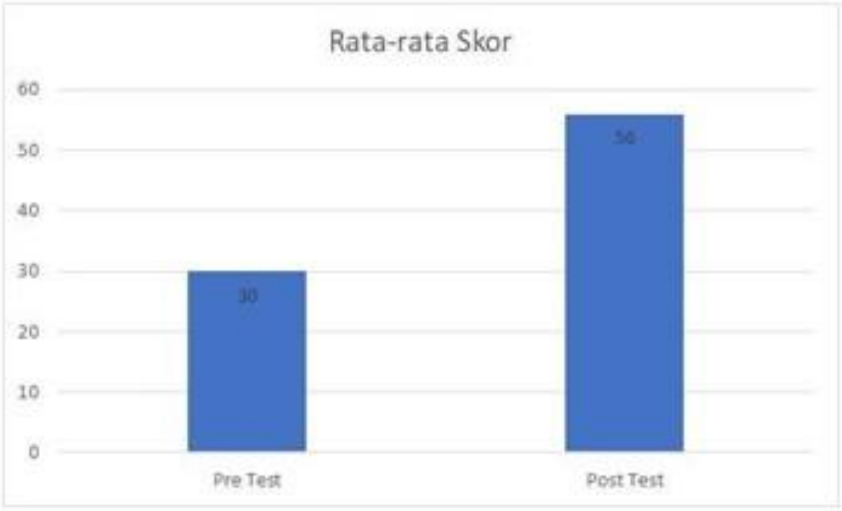


Figure 18. Increase in average pretest and posttest scores

C. CONCLUSION

Community service activities in an effort to improve the competence of SMK Roudlotul Mubtadiin students in making metal casting furnaces and kowi can be concluded that the community service activities were carried out smoothly in accordance with the objectives of this community service activity. After carrying out community service activities, SMK Roudlotul Mubtadiin students experienced an increase in competence in metal casting, especially in operating metal melting furnaces and making molds and their pouring processes. The increase in student competence is indicated by an increase in the posttest score from the pretest score of 86%.

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