Participatory ergonomics in developing e-waste collection network of UNTAR-UPH industrial engineering students

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Abstract. By using the principle of circular economy, the value of products and materials is maintained and utilized as long as possible, so that the landfill can be limited as little as possible. Electronic devices that are no longer used sooner or later will end up at the final processing site such as landfills or incinerators, where they will release toxic material into the air, soil and water, whereas the circular economy concept for e-waste can also be applied. Therefore, this research aims to make a small to medium size e-waste collection pilot project within the scope of UNTAR and UPH industrial engineering students, with participatoryergonomic approach. The research method used is action research anddata collected includes the number of core team students' participation, the amount of participation outside the core team, the form of participation, the network created, the average length of time for e-waste storage before donating, the amount of e-waste per category. In this project there were 102 students involved and divided into 19 groups. Total e-waste collected was 738 pieces.

1. Introduction

East and Southeast Asia countries have become very potential markets forelectrical and electronic equipments.Since the consumption and production of electronic products in these areas is rising, the problem of managing e-waste is increasing as well.In 2014, e-waste arising in Indonesia reached 745,231 tonnes/year or 2.9 kg per capita [1]. Most e-waste collected in Indonesia is dominated by informal collectors or scavengers and improperly dismantled by informal classifier which is hazardous to human health [1]. Meanwhile, a study conducted among 225 households in Jakarta regarding small e-waste disposal, found that only 2 % respondents voluntarily participate in e-waste recycling program [2]. Therefore, public awareness of the importance of recycling unused electronic products needs to be fostered, because there are materials that can be recycled and used by many industries.

Five R principle (rethink-reduce-reuse-recycle-recovery) is a principle of sustainable development in waste management that promotes the concept of waste as an alternative material recovery and circular economy through an integrated and environmentally friendly waste management. In the concept of circular economy, the new paradigm is built that waste is something that has value.By using the principle of circular economy, the value of products and materials is maintained and utilized as long as possible, so that the landfill can be limited as little as possible. In addition, the existence of the concept of circular economy is also supported by the concept of clean production. According to OECD, “Cleaner technologies are technologies that extract and use natural resources as efficiently aspossible in all stages of their lives; that generate products with reduced or no potentially harmful

components; that minimise releases to air, water and soil during fabrication and use of theproduct; and that produce durable products which can be recovered or recycled as far as possible;output is achieved with as little energy input as is possible" [3]. It means that the concept of clean production is not only intended to reduce waste, but also to provide possibilities in using waste as a resource.

Therefore, electronic waste collection programs need to be carried out by various parties. Based on previous research by Hanafi et.al[4], it was found that the opportunity to carry out a pilot project to collect e-waste is still widely open because the willingness of DKI Jakarta residents to recycle e-waste is quite high. From the e-waste collection project on campus which involved social networking friendship among UPH students, the average number of e-waste collected was between 7 and 12 pcs per week. Thispilot project did not incur any costs to collect small-size e-waste, because it utilized social networking, social media programs and activities with social mission and also useda participatory ergonomics approach [5].

In this study a campus recycling project was made that refers to the Capra ecological principles [6], namely the principle of interdependence, which means the behavior and existence of each participant in the program will determine the existence and development of the program as a whole; the principle of recycling which means how waste collection programs including economic aspects can be conducted more environmentally friendly; the principle of partnership and cooperation among the participants; the principle of flexibility which means the program is open to change, flexible to any changes in the form and development of its network, without losing its identity. This research also uses the participatory ergonomics approach, which involves mentally and emotionally involved people in a group or community that stimulates them to contribute to group goals and various responsibilities for what they produce.The participatory ergonomics approach requires certain conditions to be able to take place successfully, including sufficient time for participants to get involved, the benefits obtained are greater than the costs incurred, and relevant to the ability of trained people to deal with problems, enough time to communicate, how to communicate which benefits both parties, the lack of feeling forced by the other party as well as freedom of work [7].The use of participative ergonomics techniques to derive solutions is believed to develop more effective solutions as well as to result in greater "ownership" by those affected, leading to greater commitment to the changes being implemented[8]. Based on this background, the aim of this research was to develop a small size e-waste collection project within the scope of UNTAR and UPH Industrial Engineering students, in collaboration with PT Teknotama Lingkungan Internusa (PT TLI), with a participatory ergonomics approach and refers to Capra's ecological principles.

2. Research method

The research method used is action research, because the purpose of this study is to find an effective way, which can produce an intentional change in apartially controlled environment, make changes and monitor the results. Data collected are: the number of core team students' participation, the amount of participation outside the core team, the form of participation, the network created, the average length of time for e-waste storage before it is donated, the number of e-waste per category. In this project, the collected e-waste is small to medium sized such as mobile phones, MP players, tablets, laptops, etc. This action research will be designed using:

• Role Playing Techniques. In role playing, students are conditioned to certain situations outside the classroom, even though at that time learning takes place in the classroom. In this activity, students imagine themselves as if they were outside the classroom and playing other roles.

• Group Investigation Techniques: cooperative learning models that emphasize student participation and activities to find information on lessons to be learned.

• Problem Based Learning: a learning model that involves students in solving a project's problems so that students can learn knowledge related to problems, while having the skills to solve problems.

The analysis focused on the presentation of participatory management variables, which can be the key to successful participatory management as social resource to support the success of e-waste collection projects. The analysis used the ABA model: applied behavioral analysis. The ABA model framework used is an approach to promote behavioral preserving, which has three basic principles: focusing on observable behavior, looking at external rather than internal factors to improve

performance, using the principle of behaviorreinforcement [9]. The ABA model can be described as follows: 1. Define: determine the target behavior (in order to obtain effectiveness and the possibility of changing the proposed behavior), 2. Observe: observe the appearance of behavior under general conditions (note the barriers and reinforcement that are influence behavior), 3. Intervene: interventions to modify behavior (using tools such as suggestions, rewards, feedback and so on), 4. Test: test the effectiveness of the intervention.

This project will be integrated with classrooms learning: the introductory course in Information Technology at Industrial Engineering Study Program UNTAR and the PPIC Practicum at Industrial Engineering Study Program UPH. The tool used in the study was the e-waste dropbox lent by PT. TLI for 1 year for UNTAR and UPH Industrial Engineering study programs. Data will be collected using Google Classroom tools. For project publications, Instagram: IGdonasiewaste was used, to disseminate educational messages to the public "the need to care about electronic waste" in the form of e-posters & captions, as well as e-waste collection activities using dropboxes. Publication was also carried out in the FB “Peduli Sampah Cintai Bumi”, with statistical data:liked by 900 people and followed by 926 people.

3. Result and discussion

There were 72 UNTAR Industrial Engineering students from cohort 2019 participating in this project, who were divided into 13 kaizen teams of e-waste collection. The participation network of UNTAR industrial engineering kaizen teams consists mainly of friends and family. Meanwhile there were 30 UPH Industrial Engineering students from cohort 2018 and 2016 who participated, divided into 6 kaizen teams for e-waste collection. UNTAR's industrial engineering e-waste Dropbox was opened to the public from August to November 2019, with as many as 564 e-waste collected. UPH industrial engineering e-waste dropbox was opened for UPH academic community from September to November 2019, with 174 e-waste collected. Therefore, the total amount of e-waste collected were 738 pcs. The e-waste collected were categorized according to UNU guidelines on e-waste classifications [10], as follows: there were 8 types of small equipments (vacuum cleaners, personal care, small consumers electronics, portable audio and video, speaker, camera, professional tools, other small household appliances), 2 types of small IT (small IT and mobile phones), 1 type of screens (tablet), 1 type of lamps (lamps). This study was compared to the similar e-waste collection project called Recyclatron conducted at Universidad Autónoma de Nayarit, in Mexico [11]. Twenty leader students were involved in the first instance of Recyclatron, meanwhile in the fourth instance, the student’s participation increased from 20 up to 130. The accumulation of e-waste collected during the four instances of Recyclatron resulted in a total of 28,836 kg.

In this study, Applied Behavioral Analysis was used with three basic principles applied in this research, namely:focusing on observable behavior, looking at external rather than internal factors to improve performance, using the principle of behavior reinforcement. In this study, a set of observable variables was determined, such as the level of participation in carrying out the tasks.Internal factors includedphysiological aspects and psychological aspects (talents, interests, intelligence and basic abilities). While external factors consist of social aspects (teammates, classmates and lecturers) and non-social aspects (weather conditions, time, place, and facilities as well as infrastructure).In this research, it is believed that the reinforcement variables include the practical expertise possessed by each participant and the personal character of the participant that will make this project successful.

The implementation of participatory ergonomics in this project using the ABA template can be seen in table 1.

Table 1. Applied Behavior Analysis for the two projects

Project 1: Donation of UNTAR's Kaizen Industrial Engineering Team
Define: The desired target behaviorwas the active involvement of all 2019 industrial engineering students, in group work participation so that e-waste donation projects can be successful. The target behavior, project objectives, indicators, communication aids, work methods and incentives or rewards were clearly established and socialized in class; educational material and data form for project activities were uploaded in the google classroom.
Observe: Emerging behaviors during the project were grouped into participation reinforcement and

participation barrier.
Participation reinforcement:
• Transparency of information before and during the project by lecturers, especially those relating to reward/ incentives. Reward were given to students in the form of 40% weighted assignments score for participating in this project.
• Communication was quite active in the classroom as well as through Instagram.
• Students in the small size gemba kaizen team (5-6 people) showed good intention and progress.They were quite active in following the project flow, willing to work together, willing to share information and discuss for the success of the recycling project, willing to fill the project support checklist and data forms honestly.
• The lecturer and student teams were proactive, consistent and open throughout the project, especially those related to the task description and group work.
Participation barrier:
• In general, student motivation was still based on the desire to get good marks for college assignments. This of course affects the attitudes and emotions of participants during the project.
• There were some teams that did not follow the information conveyed in class project discussions. This resulted in repetition of explanation, and the lecturers must wait for the team who have not yet completed the project checklist.
• Some students were bored while running the project.
• Lack of communication between group team members, especially those related to the division of tasks and the timeliness of filling project data.
• Kaizen Team, consisting of new students (cohort 2019) who have just entered UNTAR's industrial engineering study program. Therefore, it took longer to get along with otherstudents with different cohort. In addition, the knowldege of industrial engineering courses and creative work were still quite minimal.
Intervene: Interventions to modify behavior that hinder project success were:
• Clear communication between lecturers and students, either orally in class, or through WA small group kaizen team leader.
• The lecturer gave the small group kaizen team an opportunity to immediately improve and submit late checklist and data form, so that the team could get a reward.
• Lecturers provided feedback on project progress, motivations and inspiration regarding what types of changes can be made and let student and community teams know how successful their efforts were towards expected goals.
• Lecturers gave appreciation and allowed students to give qualitative appreciation: the self-actualization of the student kaizen team
• The lecturers listened to input/ suggestions/ complaints/ expectations from all kaizen team participants, and the lecturers were willing to take necessary actions for the success of the project (such as changing steps in modules or learning process in the project to be more effective).
Test: interventions carried out during the project, were considered quite successful, based on the achievement of project success indicators: all activity checklists filled completely.

Project 2: Donation of UPH's Kaizen Industrial Engineering Team

Define: The desired target behaviorwas the active involvement of industrial engineering students in cohort 2018 and 2016, in group work participation so that the e-waste donation project can be successful. The target behavior, project objectives, indicators, communication aids, work methods and rewards were clearly defined and socialized in the classroom and arranged in a practicum module that invited students to think deeper about lean and green manufacturing in the target context which can be achieved in the short, medium and long term. In this stage, specific examples in the application of tools and methodologies, as well as some designs or ideas about green manufacturing for the future were discussed. It also introduced the Kaizen method, which is a method for creating a culture of continuous improvement and Hansei, which is acknowledge one's own mistake and to pledge improvement, which must be possessed by everyone who belongs to the Gemba Kaizen team.
Observe: Emerging behaviors during the project were grouped into participation reinforcement and participation barrier.
Participation reinforcement that affected behavior:
• Transparency of information before and during the project, by lecturers, especially those relating to reward. Rewards were given to students in the form of practicum mark on modules "Gemba Kaizen" for their participation in this project.

- UPH industrial engineering kaizen teams have learned that the UPH Industrial Engineering study program has conducted several activities of collecting and sorting PET bottles and paper waste since 2016 and e-waste since 2018. This made them realize that "Now it is our turn to get directly involved."
- Communication was quite active in the classroom as well as through WA class leader, WA Kaizen group leader and Instagram.
- Students in the small size gemba kaizen team (5-6 people) showed good intention and progress, they were quite active in following the project flow, willing to work together, willing to convey and share information, willing to gather and discuss for the success of the project recycling, willing to fill checklist and project supporting data forms honestly.
- The lecturer and student teams were proactive, consistent and open throughout the project, especially those related to group work.

Participation barrier that affected behavior:

- In general, student motivation was still based on the desire to get rewards in the form of practicum mark, so that it impacted on participants' attitudes and emotions during the project.
- There was a team that made too much planning, but could not carry out the plan, so the plan should be changed several times.
- Lack of communication between team members, especially those related to the division of tasks and the timeliness of filling project data.
- Lack of communication with lecturers, so there wasdelayed information received by the kaizen team and impeded the project activities.
- The room for conducting the Kaizen Gemba activities was too narrow.
- Dropbox location was separated from the Gemba Kaizen activity room.
- Students feel bored and sleepy because classes were held from 1:00 to 4:00 pm.

Intervene: Interventions to modify behavior that hinder project success were:

- Clear communication between lecturers and students, either orally in class, or through WA small group kaizen team leader.
- The lecturer gave the kaizen team an opportunity to immediately improve and submit late checklist and data form, so that the team could get a reward.
- Lecturers took the time to monitor the dropbox with the student kaizen team, to see the progress together, as a way to foster a sense of ownership of the joint program.
- The lecturer listened to input/ suggestions/ complaints/ hopes from all kaizen team participants, in the last Gemba Kaizen class to improve the program in the future.
- The lecturer gave each kaizen team the opportunity to talk about the success of their team to foster a spirit of competition among teams, due to the characteristics of the student teams that were quite competitive. This was expected to reduce boredom among the students.

Test:interventions carried out during the project, were considered quite successful, based on the achievement of project success indicators that all activity checklists were filled, and all the kaizen team made written reports on module implementation.

After the project was completed, the e-waste donation program using the Ecostar Group dropbox will be continued until September 2020. From observations in December 2019, the UNTAR e-waste industrial engineering dropbox has been refilled even though the work of the kaizen student team has been completed. This showed that there was a collective victory from the e-waste donation program involving a team of students and lecturers, who were able to bring narratives on how to care for their electronic waste to the UNTAR academic community. For this e-waste collection activity, the UPH Industrial Engineering Study Program kaizen team also showed great success in delivering care for e-waste narratives. They were able to reach participants from other universities in Tangerang, Bandung, Surakarta, Jember and Kediri. This achievement was in accordance with Weick’s research, that the experience to be directly involved in making positive steps will help create an effective participation experience. In addition, interventions carried out during the project by researchers, which used the paradigm of Zimmerman's learning theory, couldreduce pessimism, where the process of learning and using problem solving skills and achieving perceived control served as a psychological reinforcement that was directly influenced by the amount of participation [9].

4. Conclusion

Small-scale e-waste collection projects within the scope of the Industrial Engineering students from UNTAR and UPH, by using the participation ergonomics approach have been carried out. The number of teams involved was 19 teams and the number of e-waste collected was 738 pieces. Through the concept of shared management, the student kaizen team managed and gave up their own resources (time, energy and costs) for the success of the e-waste donation project. Participatory management greatly helped to increase participant commitment and sense of ownership of the program according to their respective roles. Social trust and the role of conscience that there were mutual benefits obtained by all participants, greatly assisted in participatory project management where participants exhibit cooperative behavior. Environmental communication intentionally built by the kaizen team of students and lecturers as narratives of concern for electronic waste, both containing knowledge and policies about the environment, has been conveyed through social media IG and FB. This has greatly helped the success of the program, both as an encouragement and motivation or as an information channel for monitoring the status of the project success.

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