Guide to Using the Set of 374 Classified Engineering for Global Development Papers from: "Systematic Review and Classification of the Engineering for Global Development Literature Based on Design Tools and Methods for Social Impact Consideration"

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1 Introduction

The paper "Systematic Review and Classification of the Engineering for Global Development Literature Based on Design Tools and Methods for Social Impact Consideration" classified 374 papers from the Engineering for Global Development literature. This was done with the purpose of helping researchers and designers find and access relevant literature to help them consider social impacts during the design process.

This document describes the categories used to classify the papers, and describes how to use the paper set to find relevant papers. The classified paper set is available for download on design.byu.edu.

This document has two goals. The first is that you will read the full version of the paper. The second is that you will use the classified paper set to build off the work of countless other researchers. The paper set contains papers specifically about all sorts of products, social impacts, and design con-

texts. No matter what field you are in, we believe that there are papers in set of 374 classified papers that will be valuable to you as you strive to design products that have a positive and sustainable social impact.

2 Attributes of Design Tools and Methods (Classification Categories)

This section describes the reasons for including each category in the classification. The individual attributes in each category are also described in greater detail. This is done for the purpose of demonstrating how the articles were coded as well as providing a list of defined terms to aid practitioners in interpreting the results of the systematic review. Categories and individual attributes may also be used for future classification of papers. This section is organized by subsections in the order listed in Section 2.2. The reviewers classified papers based on what information was explicitly included in the papers, but there were some papers that de-

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scribed methods that could be applicable to all options within a category but were not explicitly described as actually being applied to any. Having an option to include this as a possibility would be useful for future classification.

2.1 Method Purpose

This category breaks down papers by what design activities the methods in the paper would be used for. This type of breakdown has been used in previous reviews of social impact assessment and EGD literature [1–3]. Different parts of the design process require different activity types to acquire information, make decisions, or advance the design of a product. Breaking down papers in this way will make it easier to locate research containing relevant methods. The categories and definitions were defined by the authors after two rounds of preliminary classification activities.

- **Prediction Methods:** A method used to predict the impact or effectiveness of a product before launch.
- **Assessment Methods:** A method that measures or evaluates the impact or effectiveness of a product after launch.
- **Discovery Exploration Methods:** A method used to help designers consider new social impacts or gain new insights into product stakeholders.
- **Ranking Weighing Methods:** A method that helps designers determine the importance of different social impacts for a given product-stakeholder combination and make appropriate trade-offs.
- **Heuristics Frameworks:** A method that provides general guidelines, considerations, approaches, or frameworks for improving the social impact of a product.
- **Technology Development Method:** A process designed specifically for developing or advancing the design of a specific product or technology
- **Intervention Methods:** A method that focuses on the intervention accompanying a product including but not limited to: distribution, financing, policy, and the organizations running intervention efforts.

2.2 Qualitative, Quantitative, or Mixed Methods

Breaking down methods into qualitative, quantitative, and mixed categories helps designers and researchers understand the nature of the methods and their data. EGD involves factors that are easily quantifiable, such as material properties, heat transfer, etc. It also involves factors that are harder to quantify such as human decision making, product impacts on individuals, and design factors such as usability, individual preferences, etc. [4, 5]. Integrating these factors can be crucial in understanding and representing these systems [6, 7]. This classification helps researchers understand the methods being used and locate proper methods.

- **Quantitative:** Numeric data. Data that can be measured in units.
- **Qualitative:** Characteristic data, qualitative analysis, or would require quantification

- **Mixed:** A combination of quantitative and qualitative data.

2.3 Input Data Used

Classifying the data requirements helps designers and researchers understand the nature and level of data required to perform methods in papers. EGD often involves new technologies, working with new populations, and gathering data about technology adoption and impact. Sometimes this data can be gathered from secondary sources and the work of others, and other times it is necessary to go gather data. Data requirements are of great importance for assessment and other methods [3]. Additionally, data gathering can often be the most difficult and time intensive part of research methods [8]. This classification category helps designers and researchers understand the data requirements of methods on a basic level.

- **Primary Data:** Data that must be gathered by the team through experiments, observations, surveys, data synthesis, etc.
- **Secondary Data:** Data that can be acquired from existing sources.
- **No Data:** No data was required.

2.4 Global Regions & Areas Specified

The work of EGD occurs around the globe in a wide variety of contexts and locations. Some of this work may be specific to a given country, province, or city. Some work might be specific to urban or rural areas. Identifying areas specified in the paper helps those looking for area-specific information locate relevant research. Areas specified are broken down by both the global region and geographical zones specified. Individual countries mentioned in the papers were also tabulated but not used as major categories. The global regions are:

- **Africa**
- **Asia Pacific**
- **Eastern European**
- **Latin America Caribbean**
- **Western Europe**
- **None**

The geographical zones specified are:

- **Urban**
- **Suburban**
- **Rural**
- **Wilderness/Natural Environment**

2.5 Engineering For Change Industry Sector

One common method of classifying engineering products is by sector or product category. Work done within a sector often deals with the same technical and social challenges faced by others in the same or similar fields. Researchers within a sector often publish in similar sources, utilize similar resources, and work in similar contexts. The options and definitions chosen for our classification by sector are those

used by Engineering for Change [9]. Engineering for Change is an organization of more than one million professionals and maintains an extensive open source design database. Classifying papers into these sectors not only follows commonly used conventions in the field of EGD, but also helps connect the literature to the resources provided by Engineering for Change.

- **Agriculture:** Related to the growth, processing, and distribution of plant and animal products.
- **Energy:** Related to the generation, distribution, storage, and use of energy from a variety of sources.
- **Habitat:** Related to the design, construction, and repair of housing and other infrastructure necessary for providing shelter for humans and building safe, resilient communities.
- **Health:** Related to improving human health through diagnosing, preventing, and treating disease through a variety of means such as improved sanitation, environmental health, nutrition, and access to medical devices.
- **ICT (Information Communication Technologies):** Related to access to communication and information through a variety of technologies including digital means, mobile devices, sensors, software, etc. Related to leveraging these technologies for impact in other sectors. Related to ensuring fair, unbiased, ethical use of these technologies for all.
- **Sanitation:** Related to improving living conditions through improved management of human waste, management of industrial waste products, and improved access to hygiene services products.
- **Transportation:** Related to technologies and infrastructures that improve access and movement.
- **Water:** Related to technologies that improve access to, storage of, and quality of water.

2.6 Social Impact Categories

The Social Impact categories used are those identified by Rainock et al [10]. These 11 categories were identified using an extensive literature review of both engineering and social science sources. These describe the effects products have on individuals and society. Work by Pack et al. interviewed more than 50 industry professionals about social impacts and found that most industry professionals focused on Health & Safety, with the major causes given in interviews including a lack of tools or processes for other social impact categories [11]. Categorizing papers by social impact categories will help researchers and practitioners find methods for all social impact categories and may aid in a broader inclusion of social impacts in design. Definitions for each of these categories come from Ottoson et al. [12]

- **Health Safety:** Safety and security (real and perceived), activity/exercise, mental and physical health, mortality, improvement of life/ health from product
- **Paid Work:** Earning potential, industrial diversification/change in economic focus

- **Stratification:** Social capital, inequality, introduction of new classes, social status, social mixing
- **Human Rights:** Human rights, respect for Indigenous and minority rights, democracy/decision-making participation
- **Education:** Education, skills, empowerment
- **Family:** Alteration in family roles, structure, violence, stressors, ties, and role in society
- **Gender:** Gender roles, violence, stressors, inequality
- **Population Change:** Transiency of population, age structure, presence of seasonal population
- **Conflict Crime:** Potential conflicts, crimes, increased or decreased substance abuse, potential of assault
- **Social Networks Communication:** Impaired or improved personal relations, network's reliance on participation in decision-making process
- **Cultural Identity Heritage:** Weakening/strengthening of values, norms, and beliefs, cultural intolerance, personality traits

2.7 UN Sustainable Development Goals

The United Nations Sustainable Development Goals (SDGs) were set forth as a blueprint in 2015 to achieve peace and prosperity for the people and planet [13]. The SDGs have been recognized by over 70 countries and have been used as goals and blueprints for governments, NGOs, industry, and academia alike [14–16]. The UN SDGs are ubiquitous and categorizing the EGD literature by the SDGs improves the accessibility of the EGD literature to a broader community. Doing so also demonstrates what type of work is being done by the EGD community. Definitions come from the UN.

- **SDG 1 - No Poverty:** End poverty in all its forms everywhere.
- **SDG 2 - Zero Hunger:** End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- **SDG 3 - Good Health Well-Being:** Ensure healthy lives and promote well-being for all at all ages.
- **SDG 4 - Quality Education:** Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- **SDG 5 - Gender Equality:** Achieve gender equality and empower all women and girls.
- **SDG 6 - Clean Water Sanitation:** Ensure availability and sustainable management of water and sanitation for all.
- **SDG 7 - Affordable Clean Energy:** Ensure access to affordable, reliable, sustainable and modern energy for all.
- **SDG 8 - Decent Work Economic Growth:** Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all.
- **SDG 9 - Industry, Innovation Infrastructure:** Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

- **SDG 10 - Reduced Inequalities:** Reduce inequality within and among countries.
- **SDG 11 - Sustainable Cities Communities:** Make cities and human settlements inclusive, safe, resilient and sustainable.
- **SDG 12 - Responsible Consumption Production:** Ensure sustainable consumption and production patterns.
- **SDG 13 - Climate Action:** Take urgent action to combat climate change and its impacts.
- **SDG 14 - Life Below Water:** Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
- **SDG 15 - Life on Land:** Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity launch.
- **SDG 16 - Peace, Justice Strong Institutions:** Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
- **SDG 17 - Partnerships for the Goals:** Strengthen the means of implementation and revitalize the global partnership for sustainable development.

2.8 Paper Contributions

The final category for classification selected by the authors was paper contributions. Different papers have different purposes and contribute different things to the literature. Some papers provide knowledge and insights that others can use. Some describe methods, tools, or frameworks that can be used by others. The authors noted in the two classification test runs that it was hard to tell from the title and abstract of a paper whether the paper would simply recap a project, report widely applicable and useful results, or demonstrate a useful method. This category allowed reviewers to select what they believed were the major contributions of a paper so that designers or researchers searching the paper set can more easily locate the type of information they are looking for. The six category options created by the authors of this paper are:

- **Knowledge about products.**
- **Methods, tools, frameworks, or models for products.**
- **Knowledge about stakeholders.**
- **Methods, tools, frameworks, or models for stakeholders.**
- **Knowledge about Social Impacts.**
- **Methods, tools, frameworks, or models for social impacts.**

3 Using the Classified Paper Set

The variety of papers in the classified set cover different method types, social impact categories, sectors, data requirements, and use contexts. The true benefit of the classified data set is it allows designers and researchers to quickly locate papers using multiple criteria. For example, a designer who wanted to predict the education impact of a solar micro grid in a rural area would need to find a paper that satisfies a method type, sector, impact category, and geographical zone simultaneously. Such a paper exists in the paper set, but does not show up in a keyword search using terms for all four criteria previously mentioned [17].

This section will describe how to use the classified data set to locate relevant papers. Figure 14 is a flowchart that walks through this process. The steps for using the classified data set are as follows:

1. Download the Classified Data Set
2. Determine Categories of Importance
3. Determine Desired Category Options
4. Filter Data Set
5. Evaluate Results
6. Access Papers and Select Methods for Use

3.1 Download the Classified Data Set

The full set of classified papers will be available for download at design.byu.edu and https://ubwp.buffalo.edu/esdrg/. Both coded and non-coded versions will be available. Papers will be listed by row and classification by different categories and options by column. In addition to the classification information, the datasheet also includes the full title of each paper, keywords, abstract text, author names, journal of publication, year of publication, and number of citations (as of February 5th 2022).

The non-coded version will list the categorization for each paper with strings of words in each cell of a spreadsheet. This version is easier to search through manually. The coded version will be a CSV file that uses 1's and 0's for each category option with a 1 indicating a category option is applicable, and a 0 indicating an option is not applicable. A data dictionary indicating which columns indicate which options is also available and recommended for download.

3.2 Determine Categories of Importance

The next step in locating relevant papers is determining which categories are most important. These categories along with their subsequent options will be used in future steps to filter down the classified set of papers from 374 papers to a smaller more focused set.

The authors recommend initially selecting 2-3 categories of importance for use in filtering the data set. Selecting too many categories may result in narrowing down the paper set too much. Using too few categories may result in too large of a subset of papers. Categories may be added or subtracted in later steps, but best results occur from a proper selection of category.

The papers are classified by 9 different categories which are detailed in section 3 of this paper. The categories and reasons why the categories may be of important are as follows:

- **Method Purpose:** this category is important when designers are looking for methods that could be used for a specific design activity or stage of design.

- **Qualitative, Quantitative, or Mixed Methods:** this category is important if the
- **Input Data Used:** this category is important for designers who are reliant on specific data sources.
- **Global Region:** this category is important when designers believe that their work or the impacts of their work are specific to the area of the world they will be implemented in.
- **Geographic Area:** this category is important when differences between zones such as urban, suburban, or rural will likely have substantial differences in the type of work being done.
- **Industry Sectors Covered:** this category is important when designers know they will be doing work within a particular sector.
- **Social Impacts Covered:** this category is important if designers are interested in social impacts of a specific type as opposed to social impact in general
- **UN Sustainable Development Goals (SDGs) Covered:** this category is important when designers are interested in work related to a specific UN Development goal.
- **Contributions to the Literature:** this category is important if the distinction between papers that give specific knowledge vs papers that describes general methods is important.

3.3 Determine Desired Category Options

Section 3 of this paper describes each category and category options. The authors again recommend starting with 1-2 options for categories of importance. Additional category options can be added to expand subsets later if necessary.

3.4 Filter Data Set

Once category options have been selected, designers can filter down the data set and create subsets using the options previously selected. Doing so will lead to a smaller subset of relevant papers.

3.5 Evaluate Filtered Subset

At this point designers will have a smaller subset of papers. There are several ways to determine if this subset of papers is acceptable. If the number of papers is too large it is recommended that additional categorization options are selected to further filter down the subset of papers. If the number of papers is too small it is recommend to remove categorization options until the subset is large enough. if after accessing the papers, the papers appear to not be relevant or applicable, it is recommended to select different categories or category options for filtering

3.6 Access Papers and Select Methods for Use

Now that the set of 374 papers has been filtered down to a focused set of papers, designers can search for the papers by title using the academic search of their choice. The authors of this paper recommend that as designers read through the papers they take notes and pay particular attention to the methodology and results sections of each paper. These notes will help designers determine the pros and cons of the methods presented in each paper. Designers may choose to use the methods presented in a single paper, combine methods from multiple papers, or use the papers from the data set as guidance for the creation of new methods.
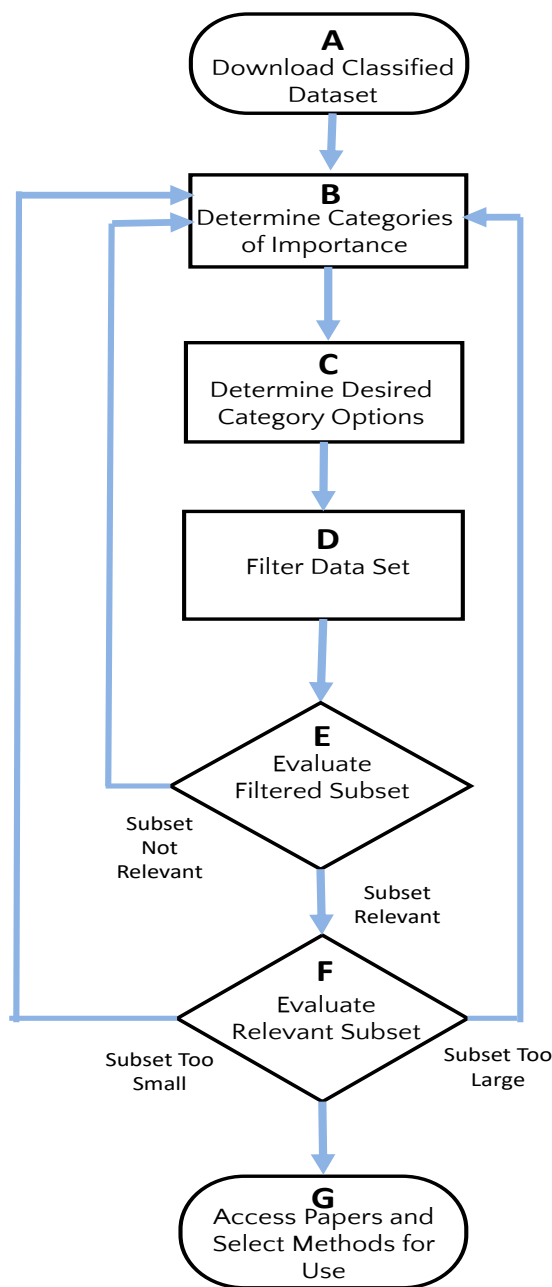

Fig. 1. Using the Classified Data Set

3.7 Additional Uses for Data Set

In addition to improved searchability, the paper set is also a useful jumping off point exploring the literature. Looking across a single category such as sector can expose designers and researchers to the breadth and variety within that area. For example, a designer in the agriculture sector going through the list sorted by agriculture might be surprised to see social impact categories not previously considered, or method types outside of what they typically use. They might be exposed to works published in journals they weren't aware of or using data sources they hadn't used before. Doing exploratory literature searches using typical search engines or databases can be time consuming and require wading through irrelevant sources to find useful sources. This curated, classified paper set not only makes looking for specific information easier, but also improves exploratory searching.

References

[1] Burleson, G., Sienko, K. H., and Toyama, K., 2020. "Incorporating contextual factors into a design process: An analysis of engineering for global development literature". In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Vol. 84010, American Society of Mechanical Engineers, p. V11BT11A009.

[2] Burleson, G., and Austin-Breneman, J., 2020. "Engineering for global development: Characterizing the discipline through a systematic literature review". In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Vol. 84010, American Society of Mechanical Engineers, p. V11BT11A011.

[3] Bonilla-Alicea, R. J., and Fu, K., 2019. "Systematic map of the social impact assessment field". *Sustainability,* **11**(15), p. 4106.

[4] Zheng, Y., Li, S., and Tan, R., 2017. "Distributed model predictive control for on-connected microgrid power management". *IEEE Transactions on Control Systems Technology,* **26**(3), pp. 1028–1039.

[5] De, S., Zhou, Y., Larizgoitia Abad, I., and Moessner, K., 2017. "Cyber–physical–social frameworks for urban big data systems: A survey". *Applied Sciences,* **7**(10), p. 1017.

[6] Dressler, F., 2018. "Cyber physical social systems: Towards deeply integrated hybridized systems". In 2018 International Conference on Computing, Networking and Communications (ICNC), IEEE, pp. 420–424.

[7] Suk, H., and Hall, J., 2021. "Connecting qualitative and quantitative analysis through bond graph modeling and system dynamics". In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Vol. 85390, American Society of Mechanical Engineers, p. V03BT03A018.

[8] Nieuwenhuizenn, P., Saling, P., Chan, K., Das Gupta, J., Morris, D., Nicole, G., Wientjes, F., Dierckx, A., et al., 2016. "Social life cycle metrics for chemical products—a guideline by the chemical sector to assess and report on the social impact of chemical products". *Based on a Life Cycle Approach.*

[9] https://www.engineeringforchange.org/. By engineers for everyone.

[10] Rainock, M., Everett, D., Pack, A., Dahlin, E. C., and Mattson, C. A., 2018. "The social impacts of products: a review". *Impact assessment and project appraIsal,* **36**(3), pp. 230–241.

[11] Pack, A. T., Rose Phipps, E., Mattson, C. A., and Dahlin, E. C., 2020. "Social impact in product design, an exploration of current industry practices". *Journal of Mechanical Design,* **142**(7).

[12] Ottosson, H. J., Mattson, C. A., and Dahlin, E. C., 2020. "Analysis of perceived social impacts of existing products designed for the developing world, with implications for new product development". *Journal of Mechanical Design,* **142**(5).

[13] Assembly, G., 2015. Resolution adopted by the general assembly on 11 september 2015. Tech. rep., A/RES/69/315 15 September 2015. New York: United Nations.

[14] Biermann, F., Kanie, N., and Kim, R. E., 2017. "Global governance by goal-setting: the novel approach of the un sustainable development goals". *Current Opinion in Environmental Sustainability,* **26**, pp. 26–31.

[15] Bali Swain, R., and Yang-Wallentin, F., 2020. "Achieving sustainable development goals: predicaments and strategies". *International Journal of Sustainable Development & World Ecology,* **27**(2), pp. 96–106.

[16] Bexell, M., and Jönsson, K., 2017. "Responsibility and the united nations' sustainable development goals". In Forum for development studies, Vol. 44, Taylor & Francis, pp. 13–29.

[17] Suk, H., Sharma, A., Nellippallil, A. B., Das, A., and Hall, J., 2021. "A framework for improving rural microgrid sustainability through integrated socio-technical considerations". In *Design for Tomorrow—Volume 3*. Springer, pp. 285–295.