

Journal Pre-proof

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The Future of Development Engineering - Our Vision for the Next Generation of Publications in DevEng

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Introduction

Engineering plays an important role in advancing the Sustainable Development Goals (SDGs). It contributes to a wide range of innovations, from the development of vital technologies such as solar water treatment systems [1] or cookstoves [2], and new tools to assess progress towards the SDGs [3], to innovations in the design of decision-making environments and systems-level thinking on how development is achieved. Many researchers, aid agencies, and NGOs are currently involved in designing, implementing and evaluating engineering-based innovations, taking promising technologies and policies from controlled laboratory environments to the field. Along the way, they gain tremendous insights into the innovation process. However, these insights are often left in the realm of best practices, published in domain-specific journals that are not accessible to the development community, or disappear in appendices of manuscripts that are published years after the innovation was tested or prototyped. As a result, subsequent teams often do not build upon the lessons learned by other teams, and are left to develop their own innovation processes. Moreover, these processes often fail due to technologies not being vetted well enough, field tests not being comprehensive, and evaluations lacking rigour. Unfortunately, the most vulnerable pay the price when we so often produce ineffective solutions to poverty, and when we cannot produce new solutions without re-inventing the wheel.

Published engineering research often focuses on the domain specific details, and on how the work relates to other engineering literature in that domain, rather than on how the proposed innovations interact with human behavior and the unique norms and institutions in the “real world” development contexts. For engineering solutions to have an impact towards the SDGs, these other factors need to be considered. As illustrated in Fig 1, factors such as the various potential business models behind these solutions, manufacturing processes, distribution channels, the policies, institutions and markets through which these solutions are delivered to the end consumer, and the behavioral response of the end consumer all have a significant impact on the overall costs and benefits of the

intervention. Innovations should be culturally appropriate for the context considered and existing norms through which they could exacerbate existing inequities need to be addressed. It is critical that these interdisciplinary and socioeconomic aspects are discussed in the context of engineering research for global development.

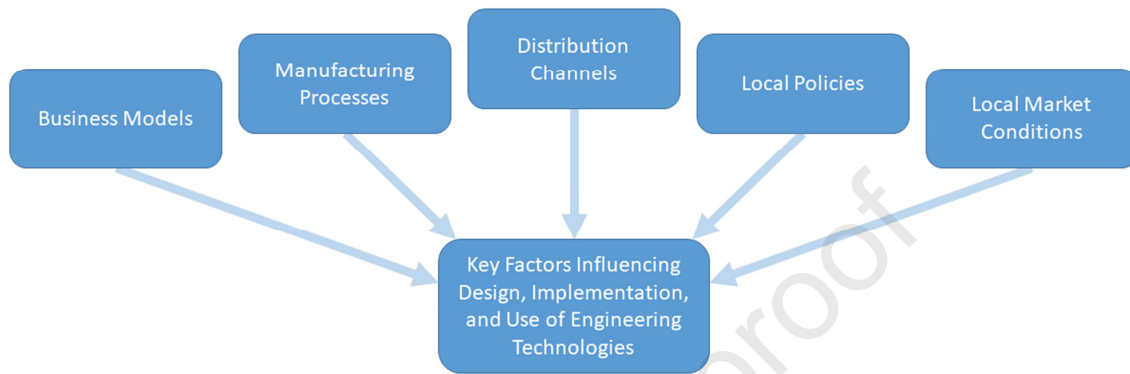


Fig 1. Factors Influencing Design, Implementation, and Use of Engineering Technologies

Development Engineering was created in 2016 under the leadership of Professors Ashok Gadgil and Paul Gertler from the University of California Berkeley to fill these critical gaps. The journal has published many widely cited articles providing important insights for different readers of the journal, some of which we will highlight below. As new editors, we are thrilled to take over the leadership of this journal. Our vision is to further develop the journal to publish development engineering research that meets the highest quality standards, provides our readers with the latest insights on solutions and applications from development engineering, whilst providing researchers with a platform to disseminate their findings for a wide audience in a timely manner, with a rigorous yet rapid review process in which we welcome manuscripts that highlight lessons learnt from early phases of a research project.

Our goal is to build a community for researchers, practitioners, and policymakers involved in engineering for global development; a place where they can come together and share important findings and insights generated from our work. Through this, we aim to support engineering solutions in reaching their intended impact on the SDGs. Work published in Development Engineering, as a multidisciplinary journal, is by nature geared towards a broad audience, not only to experts in the field. We strive for Development Engineering to have development relevance and be of interest, and indeed read by a broad range of researchers, students, practitioners, donors and policymakers. We will discuss how we ensure that the articles are accessible for each of these audiences below.

About us

To enable efficient and appropriate review of the publications, the editorial team of Development Engineering is a multidisciplinary team. We would like to take this opportunity to introduce ourselves and our expertise:

- *Dr. Susan Amrose: engineering - environmental*

Susan is a Research Scientist in the Global Engineering and Research (GEAR) Lab at the Massachusetts Institute of Technology. Her research focuses on identifying opportunities for disruptive innovation and creating technologies that improve lives in resource-constrained communities. GEAR lab blends socioeconomic and market analysis with rigorous engineering to create both novel scientific knowledge and positive social impact. Susan has used this process, both at GEAR Lab and the University of California, Berkeley, to develop profitable water treatment to reduce chemical contamination and salinity, affordable drip irrigation for smallholder farmers, and environmentally-sustainable building materials for low-income housing. She is interested in this process of using socioeconomic insights to focus engineering effort towards impactful research questions, and the translation of new knowledge into sustainable and marketable solutions in highly constrained environments. She sees the need for a journal dedicated to the community of scientists and engineers struggling to create lasting impact in these demanding environments. As a co-editor, Susan looks forward to strengthening this global and interdisciplinary community, and cultivating a rigorous forum to address its most difficult challenges.

- *Dr. Amy Bilton: engineering - mechanical and design*

Amy is an Associate Professor in Mechanical and Industrial Engineering at the University of Toronto. She also serves as the Director of the Centre for Global Engineering (CGEN) at the University of Toronto, which is a cross-disciplinary centre that focuses on catalyzing research and educating future leaders in the area of Engineering and Global Development. Her research group, the Water and Energy Research Laboratory (WERL) develops innovative technologies to improve sustainable use and access to water in low and middle income countries. Applications of her work range from water treatment to effective use of water in agriculture/aquaculture. Her group uses human-centred design and collaboration to go from problem definition, to concept development, prototyping, field evaluation, and eventually scale. She's currently excited to see the next steps for several technologies being commercialized by spinoffs from her group. Given the broad range of considerations which come into successful translation of technology in the global development context, Amy sees the need for a journal for researchers and

practitioners to share their best practices. In her role as co-editor, she is looking forward to continuing to grow the Development Engineering community.

- *Dr. Berber Kramer: social science / economics*

Berber is a Research Fellow with the International Food Policy Research Institute (IFPRI), an international organization that provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition in developing countries. As an applied microeconomist, her research aims to enhance our understanding of behavior in low- and middle-income countries where information asymmetries, weak institutions, and poorly functioning markets shape the decision-making environments of the poor. She is particularly interested in the mechanisms to accelerate the adoption of new technologies, and the potential for these innovations to transform markets and institutions, enhance investments, and boost economic development. In recent years, she has focused on the design and evaluation of innovative crop insurance and agricultural credit products for smallholder farmers, using smartphone images of crops to reduce information asymmetries in financial markets. As a researcher in the CGIAR, a global agriculture innovation network, she has first-hand experience working with multidisciplinary teams, and the value of sharing findings already at early stages of the innovation process with fast turnaround times. In her role of DevEng editor, she is therefore passionate about publishing findings from development research in a timely manner, so that readers can act on the insights from such research and improve the lives of the poor and vulnerable communities who devoted their time and resources to participate in the research.

What fits in the journal

The goal of Development Engineering is to provide both social scientists and engineers with an avenue for disseminating their research regarding the engineering of solutions for development and poverty alleviation. This includes deployment of these solutions in developing countries with their unique challenges and institutions; aspects related to impact evaluation and the costing of these solutions; engineering-based innovations in measurement for evaluation and decision-making, for instance through sensors to track progress towards development, or leveraging geospatial data to aid decision-making; and resulting policies related to global development. This can result in a breadth of topics, with the journal spanning a wide range of sectors and innovations, which we will discuss below.

Given the focus on development solutions and the broad readership of the journal, it is important for these papers to include a discussion on the impact of the technology on poverty or inequality reduction, or to relate their research with other human development objectives. In describing

their relevance for this field, papers could consider a broad range of dimensions of health, economics, policy, and governance; Development Engineering welcomes solutions from different types of sectors that contribute to development. Because of the broad readership, and our hopes that policymakers and practitioners act upon the published work, we also consider it our responsibility to ensure that research methods are of high quality and that policy implications are carefully scrutinized, so that the findings and conclusions are indeed reliable enough to inform further innovations in resource-poor environments.

A commonly asked question is whether solutions published in Development Engineering need to be a new technology, or whether articles need to be written by interdisciplinary teams. This is not the case. For example, one study used community-based and participatory design, coupled with rapid prototyping, to modify a teaching curriculum on water, sanitation and handwashing practices to better suite users' needs and local conditions [4]. **We also want to stress that engineering is broader than designing technological solutions**; development engineering can also focus on systems improvement, or on choice engineering, to reduce poverty. Studies on choice architecture or nudging [5] are welcome in the journal Development Engineering. Modifying the decision-making environment, for instance by presenting a desired behavior as the status quo, could help people make better decisions, and thereby contribute to poverty alleviation.

Design processes for low- and middle-income countries

One important area of work on which we publish covers research on the design processes of engineering solutions for a context that is particular to emerging markets or developing countries. This includes prototyping methods and constraints in design in the context of LMICs. For instance, a study published previously in the journal focused on prototyping solutions for small-to-medium sized enterprises in East Africa [6]. Studies could also describe how engineering design and prototyping in a development context are used in subsequent innovations in the developed world context, as highlighted in a reverse innovation case study that treated developing world users as lead users [7]. Other studies may focus on how to balance competing technical and user perspectives in the design of development solutions, as illustrated in a study on the design of cookstoves [8].

A second strand of research related to design processes analyzes the design requirements for a certain technology in order to be viable in a certain location or socioeconomic context. This type of research can consider multiple dimensions and perspectives, including engineering and economics. For instance, previous research published in Development Engineering has focused on integrating usage

context, user behavior, and technology performance in design for clean technology adoption [9]. Another example determined the potential economic viability of off-grid electricity by estimating consumers' price elasticity for the solution [10]. Relatedly, studies could use secondary data to test whether the assumptions behind the proposed solutions are valid; for instance, despite ambitions of governments and donors to invest in rural electrification, a study in Kenya used radio frequency identification data to show that electrification rates are low even with nearby grid infrastructure, raising questions around the validity of the assumptions behind investments in rural electrification [11].

A third area related to the design process focuses on design, optimization, and robustness of technologies in a low- and middle-income country setting. For instance, Development Engineering published a first study on how optimization and robustness evaluation can be used to improve technologies to lift people out of poverty [12], and another study highlighting the application of modular product design for developing income-generating technologies [13]. In the last example, designers identified a relatively complex product, currently unaffordable for someone living in poverty but with income-generating potential, and decomposed it into sub-products designed to be useful and affordable as stand-alone products. Individuals living in poverty could then share the purchase of the complex product with others in their community by having each person buy independently useful portions (or sub-products) of the complex product.

Evaluation of development solutions

Another important area in which we welcome manuscripts relates to the evaluation of development solutions in the field. This includes lessons learned from pilots and research trials, including early phases of randomized controlled trials and other quasi-experiments; along with insights on how the solution evolved and was improved through these research trials [14, 15]. We also welcome proofs of concepts, including formative evaluations or feasibility studies for innovative solutions that have not previously been tested. One study, for instance, analyzed whether visible damage to a farmer's crops is visible from smartphone images, and whether farmers can be expected to send in images of their crops, to answer the question whether such images can be used for crop insurance claims settlement [16]. An area of particular interest, where we would like to see more submissions, are articles that document why promising development solutions did not work out when introduced in a development context, including an analysis on what was driving the failure. These submissions are important for advancing learning about what does not work.

It is also important to understand how to structure studies to do this type of evaluation and we welcome more submissions on this topic. This could include for instance the design of randomized controlled trials to evaluate a development solution, with an example of a prior publication discussing how to ensure proper randomization with balancing of observed variables across treatment and control [17]. One could also think of strategies to evaluate successful field deployment, with an example published earlier from a study on arsenic removal systems [18].

New tools and methods to facilitate evaluation

An important area for Development Engineering brings together engineering and development economics by documenting new tools and methods to facilitate evaluation. In evaluations of development solutions, an important question is how to measure one's primary outcome and impact variables; and engineering research has created a wealth of tools with use cases for economic evaluations, including the use of remote and in-situ sensing, for instance using geospatial data for development [19], sensory to monitor air quality [20], monitoring cookstove and fuel use [21], or wearable sensors for agricultural and rural energy expenditure [22]. We also welcome manuscripts documenting when a new measurement method does not work, as was illustrated by a study on radio frequency identification [23].

We also welcome publications that evaluate platforms for data collection for impact evaluation [24], or studies that compare alternative survey methods and guide researchers in future survey development [25]. Data collection for the purposes of an evaluation can have direct impacts on the behavior that is being evaluated, and we find it important to publish in this area as well, as illustrated by a recent publication on whether financial diaries introduce Hawthorne effects [26]. To further facilitate evaluation, one could think of social impact metrics that can be compared across development solutions [27].

Evaluation is not only about analyzing the benefits that a development solution can deliver to its end users; an important component in evaluation for Development Engineering is cost. Cost plays a dominant role in the design of products and services for marginalized populations. Affordability is a key design requirement for financially-constrained markets; cost is the primary metric of comparison between competing innovations; and improvements in the design of innovations often focus on reducing costs. Yet, in spite of this dominant role, it is rare to find discussion or critique of different cost evaluation strategies, or to find uniform methodologies for cost evaluations. Cost data are treated differently from other types of data; uncertainty is rarely estimated, and in many cases, evaluation

methodologies are not fully or transparently described. These issues make it difficult to compare cost estimates between studies or to critically evaluate the cost estimates that are at the center of many policy and technology recommendations. One example which successfully looked at these aspects was a study which evaluated the costs, and associated uncertainties, of different methods to diagnose pre-eclampsia [28]. We welcome more submissions on this topic and have launched a special issue to publish more studies that discuss how to evaluate development solutions in terms of costs.

Business models and policy to support development

Evaluation is only part of the development process. In order to ensure that engineering work conducted to aid in global development is sustainable and generates long-lasting impacts, it is essential that there are business models and supporting policies in place to promote the development, scaling and utilization of engineering solutions. As this is a vital area where expertise from engineering and economics come together, we hope to see more research around enabling business models and policies being submitted to Development Engineering. Examples of work in this area include previous published articles on how NGOs and multinational organizations could work together to develop new business models to support essential technologies in development markets [29], or studies that are aiming to understand how different social entrepreneurship models can be applied to support global development [30]. We would also welcome research that tests the cost-effectiveness and sustainability of alternative business models to scale out demonstrated technologies, experiments on incentives for private sector actors and mechanisms designed to enhance the cost-effectiveness of such business models, or studies that analyze the impact of policies intended to promote the acceleration of new technologies, all with the potential to result in improved development and enhanced wellbeing for the poor.

Data to support development

Data is essential to evaluate the impact of development interventions and understand the problems associated with poverty. However, in low-resource settings, data is often very scarce. The abundance of geospatial data now available through satellites, sensors, and mobile phones has potential to fill these gaps. This data can be processed with analytical tools and combined with “ground truth” from surveys, administrative data, and other sources to understand development challenges. This type of data has been used in a broad range of applications including using satellite mapping to understand forest conservation [31], using de-identified call records to identify commuting patterns related to urban mobility challenges [32], and using data from online social networks to identify false posts to cause

sentiment changes in the population [33]. Many more areas have potential for impact from geo-spatial data, including agriculture, health, poverty, transportation, water and sanitation, and humanitarian relief. Despite these examples, applications tend to be underutilized in global development due to the perceived complexity of the geospatial data and the gaps between researchers and policymakers. We have recently launched a special issue to focus on the applications of geospatial data in global development to help fill the gaps in this important area.

Shaping the field of Development Engineering

Since development engineering is still emerging as it's own field, we also welcome work which overviews the topic, how the field is taught to future leaders, and what is really needed in academia and its interaction with policymakers and practitioners to enable future growth. It is especially important in development engineering to understand mistakes of the past and use these aspects to understand how the field has evolved. Given the integrated nature of many development problems, it is critical that this work takes a holistic viewpoint. Important examples of articles in this area include those that document experiences with different development engineering projects and develop guiding principles for the field [34], or articles that review the current state of technology development to demonstrate the need for research in this area [35, 36].

As an emerging topic, a number of institutions are developing their own curricula to educate future engineers and scholars to make an impact in this area. It is important to share best practices from institutions that have already established programs to enable the field to grow. We welcome articles around this topic in Development Engineering. This can include both big picture thinking about the overall curriculum development and pedagogy of these programs [37] and detailed descriptions of individual course design and field experience work [38]. In all cases, these discussions should include a critical assessment of the programs or courses presented in order to enable other educators to understand their potential impact.

Finally, as an evolving field, we value articles that advance our understanding of what else is needed in academia to allow development engineering to keep growing as a field. In many institutions, the requirements behind tenure and promotion do not always agree with the impact oriented nature of development engineering. Funding opportunities are also not always as available to research in this area. This can make it difficult, particularly for junior academics, to really become engaged in this field. We would welcome papers on the topic that use high-quality research methods to analyze and describe

what changes need to happen, are currently happening, and why certain considerations are being left behind.

Other Goals

While our main objective is to advance the field and publish development engineering research of the highest quality standards, the development oriented nature of the journal inspires us to ensure that the journal is accessible to scholars and practitioners in low and middle income countries (LMICs). The journal is therefore open access only; all papers can be easily accessed regardless of someone's affiliation with an academic institution and the journals to which one's institution subscribes. We also want to highlight that we welcome authors from LMICs. To remove barriers for publication for scholars from LMICs, fee waivers are available; an overview of eligible countries is provided on the website of the journal. Moreover, we are excited to announce that we have a mentorship program available through which researchers and practitioners with high-potential manuscripts can work with researchers who are more experienced with the publication process to improve their submission quality.

We also note that Development Engineering is meant to support a broad audience engaged in engineering and global development, from researchers, to policymakers and development practitioners. While the papers need to have the technical rigour and originality associated with high quality journals, the papers should provide the appropriate context on the development problem being addressed to a general and interdisciplinary audience. Policymakers and scholars alike should understand the implications of the work and why the paper is important to those working in the development field.

Conclusion

We hope that Development Engineering will continue to grow and fill the vital gap which links the details of engineering research for global development with the important socioeconomic context. Development Engineering can provide an essential community for those in the area of engineering for global development and a place for researchers, practitioners, and policy makers to come together and share important findings on how to use innovations arising from engineering for economic development. We welcome submissions from a broad range of disciplines and especially authors from LMICs. We hope to see many high quality submissions over the coming months and years. We are also very approachable, and would like to encourage our readers and those with potential manuscripts to reach out to us in case of any questions.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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