Understanding Student Perceptions of Project Impact in the EPICS in IEEE Service-Learning Program

Stephanie Gillespie
Tagliatela College of Engineering
University of New Haven
West Haven, CT, U.S.A.
sgillespie@newhaven.edu

Steve E. Watkins
Electrical and Computer Engineering
Missouri University of Science & Technology
Rolla, MO, U.S.A.
steve.e.watkins@ieee.org

Ashley F. Moran
EPICS in IEEE
IEEE
Piscataway, NJ, U.S.A.
a.f.moran@ieee.org

***Abstract*—This innovative practice full paper addresses the assessment component of student service-learning projects. Through IEEE, the Engineering Projects in Community Service in IEEE committee (EPICS in IEEE) sponsors service-learning projects for student groups in project areas spanning human services, environmental, access and abilities, and education and outreach. Service learning and community-engaged learning can provide positive outcomes for both the students and the community organization or community members. The intent of assessment in a service-learning project or program is that both the student-learning outcomes and the humanitarian/community impact of the implementation or engagement are gauged. Often, the latter aspect of assessment is less developed than the former.**

This work explores best practices for developing and proposing an assessment plan for community impact in the context of EPICS service-learning projects. Over 90 EPICS in IEEE proposals from groups worldwide were evaluated. Recent proposals submitted to the EPICS in IEEE program for funding consideration were analyzed to compare the level of detail and types of assessment proposed. This data is compared to the EPICS in IEEE rubric criterion for assessment, and also to service-learning and humanitarian best practices for effective assessment. Examples from these proposals highlight student perspectives and understanding of assessment approaches; future resources and guidelines can address areas of concern to aid students preparing proposals, reviewers applying the rubric, and educators engaged in project supervision. Recommendations are described that can improve the student and community assessment strategies for future EPICS proposals, other service-learning activities, and technical project planning in general.

Keywords—service learning, EPICS, humanitarian project assessment

I. Introduction

IEEE's mission statement specifies, "IEEE's core purpose is to foster technological innovation and excellence for the benefit of humanity" [1]. One way in which IEEE has been working towards this purpose is by supporting humanitarian engineering projects. These projects often focus on collaborating with local communities to design and implement technical solutions to improve humanity. Multiple programs within IEEE contribute to this mission, such as those supported by the IEEE Humanitarian Technologies Board [2].

In order to avoid projects that fail in the community, most programs that fund humanitarian projects within IEEE encourage significant planning, support from the community, and assessment methods. Appropriate planning can ensure the project is able to succeed not just at the time of deployment of the solution to the community, but in the years of community use after the deployment. While technical success is one part of a project that can usually be easily measured at the time of deployment, other more long-term measures of success might attempt to assess the positive or negative impact of a project on a community. An appropriate assessment plan for community impact can be an important part of post-project deployment, helping teams to identify the successes or shortcomings of the project for future refinement and learning.

EPICS in IEEE is a service-learning program within IEEE that intends to benefit both students and communities [3,4]. The assessment of community impact from EPICS project is important to measure. This paper examines existing research on humanitarian engineering project impact and EPICS project impact in particular, and explores to what extent impact assessment is included in a subset of EPICS in IEEE projects. The paper concludes with best practices for community impact assessment and suggestions for service-learning practitioners to emphasize assessment with their pedagogy and project support.

II. Background and Literature Review

A. Measuring and assessing impact in communities

How do we measure the impact of a humanitarian engineering project on the community? Often, humanitarian impact attempts to assess either a comparison to the community before/after a project was implemented, or by comparing to other similar groups who did not receive the intervention [5, pp. 5]. Proudlock et al. comment that impact can be measured with both qualitative or quantitative data, but most successful assessment strategies will utilize both complementary types. There is often a discussion of scoping and timing of when to measure the long-term impact from the project. Another common aspect of impact assessment is community participation in the planning and assessment strategy.

The Organization for Economic Cooperation and Development/Development Assistance Committee defined a model where project activities directly result in outputs, but these outputs may lead to future outcomes and future impact [5, pp. 16]. An example by Hoffmann et al. cited in Proudlock et al.'s chapter demonstrates outputs vs outcomes for a program to implement a measles immunization program [5, pp. 22].

Immediate indicators of the program's implementation might include the number of people trained, the number of vaccines administered, and the percentage of the population vaccinated. Long-term outcomes might include a decrease in the number of measles cases and/or decreased mortality rate. This model emphasizes that impact is usually not able to be measured until well after the project activities have concluded and the community has changed because of the humanitarian intervention. Vanclay et al. suggest social impact assessment should include the affected communities and includes discussion of construction a social baseline through surveys, interviews, or profile creation, identifying indicators to monitor for change, creating and implementing a participatory monitoring plan, and evaluating with periodic review [6]. Lynch et al. used pre-interviews, post-interviews, and focus groups with the community partners to integrate the assessment throughout the project duration [7].

With challenges in identifying exactly how to define impact, humanitarian impact can be challenging to assess. Proudlock et al. highlight that "humanitarian impact is complex and difficult to assess," which is why there is often a low-frequency of impact assessment attempted in humanitarian spaces [5, pp. 10]. As part of the literature review, this paper's authors systemically examined publications from the IEEE Global Humanitarian Technology Conference (GHTC) to understand what types of assessment methods were documented related to humanitarian projects in the area of engineering and technology. A review of the most cited papers from 4 years of conferences (including both pre-COVID-19 pandemic and post-COVID-19 pandemic conferences, 10 papers per conference) resulted in very few papers included discussion or results from community impact assessment. Many papers suggest community impact by citing improved technological abilities without providing details of how they would assess use of their solution or long-term impact. As examples, Solpico et al. suggest increasing UAV coverage area for disaster response teams, and Alves et al. suggests that a digital twin for smart farming can result in better resource consumption and ultimately impact crop yield [8,9]. A small number of the reviewed papers did include assessment plans: Agbana et al. discuss visiting stakeholders to discuss the ideas and needs of the community before starting the design process using expert interviews, focus groups, and demonstrations of early prototypes to collect feedback during the design process [10]. The authors planned additional feedback from stakeholders after the project was completed. Ngai et al. implemented remote STEM education to children during the COVID-19 pandemic [11]. Their work measured the impact of their project by collecting feedback from community partners and parents (both considered secondary stakeholders since the children were the primary stakeholders). IEEE Smart Village and IEEE SIGHT used the framework of social return on investment (SROI) to relate the value of project benefits to the value of project investments [12-14]. Paddock used community health and school-absence metrics to assess the ten-year impact of two Engineers Without Borders projects [15].

B. Service learning in engineering

Service learning is a pedagogy that links student academic learning to solving real community needs. Duffy et al. suggest service learning is a type of hands-on learning, often linked to credit-bearing courses, and includes elements of reciprocity, reflection, coaching, and community voice in the projects [16]. Natarajarathinam et al. discusses service learning in the context of community engagement [17].

Criticisms of the term service learning often relate to concerns regarding the simplification of community problems and teaching a false understanding of how to respond to a need [18], or concerns of reinforcing deficit perspectives and stereotypes [19]. Community engaged learning is a broader term than service learning in that it includes activities that may be happening outside of a formal classroom setting [20]. Some service-learning practitioners prefer to exclusively use or append the term community engaged learning to emphasize the reciprocity desired between the students and the community that minimize the potential community harm from service learning alone [21].

C. EPICS in IEEE overview

EPICS in IEEE [22] was founded in 2009 within the oversight of the IEEE Educational Activities Board. The program was based off the EPICS program founded at Purdue University in 1995 [23]. The program was created to not only provide community service organizations with appropriate technology solutions to improve their community offerings, but also to provide undergraduate students with educational experiences that broaden their skills. The projects are often integrated into curriculum that can be part of accreditation purposes [24]. The program supports student service-learning proposals in the areas of access and abilities, education and outreach, environmental, and human services. Support includes financial support for projects, mentorship, educational resources for best practices in service learning, and connection to a service-learning community.

Selection for financial support by EPICS in IEEE is through a review process based on a comprehensive proposal. While the EPICS in IEEE project itself provides the technical service-learning benefit to student participants, the preparation and implementation of a well-crafted project proposal also provides important value to the student experience. The review guidelines are described in an evaluation rubric which has been recently refined. A detailed assessment plan is a part of the criteria that must be addressed by the proposal, and must be customized to the proposed project scope. In particular, the EPICS in IEEE committee has added a stronger focus on assessment plans in the project proposal process in recognition of the critical real-world link between project effectiveness and pre-planned assessment activities. These changes reflect a growing concern by the committee that cohesive and realistic strategies for community impact were a problem. Such shortcomings may be due to the lack of clear best-practices and evidence-based research to document how to teach engineering students to critically evaluate community impact (rather than evaluating against technical specifications).

D. Impact assessment of student service-learning projects

Ravel emphasizes service-learning assessment attempts to "balance between achievement of the project goals and individual learning that takes place from the successes and failures" [25].

The authors found minimal prior work documenting effective training of engineering students to develop and evaluate community impact from their projects. Instead, most published assessment of service-learning focuses on student learning outcomes [26,27] and student perceptions [28,29].

III. EPICS in IEEE Proposal Review Process

The intent of the EPICS in IEEE program is to satisfy dual goals of student learning and local community impact. A recommended perspective for proposal preparation is to consider the technical design process and the community impact assessment process as parallel efforts. Proposals for EPICS in IEEE are submitted through a web-based platform as a form with many fill-in-the-blank sections and required uploads. During a review process, a rubric is used to evaluate the submitted proposals.

A. Proposal components

Project proposals are considered in the context of problem solution with significant service-learning by students. The scope is limited to one-year project durations. The documentation progresses from a problem statement to the assessment plan with the following key elements:

- Problem Summary and Justification,
- Description of Partnering Community Organization and Their Role,
- Proposed Technological Solution and Innovation,
- Project Description (Budget, Timeline, Team Composition, etc.), and
- Impact and Assessment Plan.

B. Proposal evaluation with the EPICS in IEEE rubric

The required sections of the proposal address the categories which are used in the proposal review rubric, see Table I. Details on the Impact Assessment portion of the rubric is shown in the Appendix 1. Impact assessment is both a proposal section and a rubric category. Generally, project submitters define their assessment plan in the Project Impact (Impact Assessment) section of the proposal, but other sections may have elements that contribute to a well-developed assessment. For instance, the project description may note community involvement/feedback in the design process and the other sections may indicate the technical benchmarks needed to address the project problem adequately.

EPICS in IEEE reviewers complete a training and use the rubric to guide their proposal evaluation. When evaluating the project impact proposed throughout the proposals, reviewers may look for various types of assessment methods. One measure of impact is the number of people in the target community which can benefit from the project deliverable in the short term and from wider implementation in the long term. Technical measures may be included to show how the device or system performance addresses the stated problem from a technical perspective. Finally, measures must be proposed to show how the technical work solves or mitigates the stated problem from a community or humanitarian perspective. The plan for these final measures should describe how the impact data (qualitative or quantitative) is collected. Proposal weaknesses can include insufficient, vague, or unrealistic measures and lack of a clear data collection process. In some proposals received, assessment appeared to be included as an afterthought and not as a well-integrated activity throughout the project timeline. Proposal reviewers over the 15 years of EPICS in IEEE have observed that students can struggled to fully develop an assessment plan, even when the design elements are strong.

TABLE I. Categories in the Project Review Rebric [22]

Rubric Category	**Description**
Engineering Design	Are students engaged in the design process?
Level of Innovation	Is the solution innovative compared to existing solutions?
Non-Profit Alignment	Does the project align well with the needs of the partner?
Project Budget	Is the budget reasonable?
Deployment & Sustainability	What group will continue or sustain project implementation after the project is complete?
Learning Outcomes	Does the proposal outline the learning outcomes for students?
Impact Assessment	Does the project have reasonable impact numbers and an assessment plan?

IV. Methods

The analysis described below was performed to attempt to answer the question: to what extent do submitted EPICS in IEEE proposals include thorough and literature-supported impact assessment methods to assess community impact of their projects?

A. EPICS in IEEE proposal selection for analysis

This analysis was limited in scope to the complete proposals submitted in time for the 2023 "Fall Call for Proposals" which had a focus on environmental and climate change projects. These proposals were submitted through the online platform managed by EPICS in IEEE by the November 1, 2023 deadline. Proposals were submitted from across the globe, with the largest number submitted from India. A total of 170 proposals were submitted from around the globe. After the EPICS in IEEE committee review process in, 22 proposals were selected for funding, and the rest were not funded. The proposals reviewed from the November 2023 deadline were selected for analysis for this study because the committee had recently modified the impact questions. In specific, the general expected number of beneficiaries had been split into two questions: a short-term impact number of expected beneficiaries (1 year) and a long-term impact number of expected beneficiaries (3 year). A new proposal section and rubric question were also added with the language: "Project Impact: Describe how you will assess if the project was a success. Estimate the number of people that will benefit from the project. Where applicable, provide geographic areas, gender, age group, etc."

B. Codebook creation

A codebook of different community impact assessment methods was created from the sources identified in both the general literature review and the systematic GHTC literature review, in addition to features that the committee members look for based on the EPICS in IEEE proposal evaluation rubric. These codebook features are described in grouped categories below:

- Pre-deployment and Post-deployment Assessments. Examples include using surveys, interviews, or focus group discussions to collect user or secondary-stakeholder feedback or guidance to on the impact of the solution and interventions.

- Community Engagement. The target community or key representatives can be part of the design and deployment process. This approach may include community representation on the design team and/or community training or orientation as part of deployment of the solution. General feedback can be collected to guide future iterations of the technical solution.

- Technical Performance. The technical solution performance can sometimes be used to quantify the extent to which a project is impacting the community. For instance, a project may hope to achieve a specific level of improvement measurable by sensors to compare to a benchmark.

- Impact Metrics. The resulting community impact of the technical solution may be compared quantitatively or qualitatively. This may include looking at the number of individuals to utilize a system, comparing community outcomes beyond technical results of the project to baselines, etc.

A full list of all codebook items within the categories is included as Appendix 2.

C. Codebook validation

The first two authors (referred to as the coders) created the codebook from the literature. The intent of the codebook was to assign a binary "1" if the specific community impact assessment item was present in the proposal, or a "0" if not included. An initial test of the codebook was completed by having the two coders each individually code the same set of ten submitted proposals with the preliminary codebook. Seven of the proposals were selected from the funded proposals, and three from the not-funded proposals. The coders piloted the codebook with a heavier emphasis on the funded proposals after hypothesizing that funded proposals should have more impact assessments described since impact assessment is one of the rubric criteria for EPICS in IEEE funding. The coders reviewed various sections of the project proposal, including the problem statement, project description, project inputs, project activities and outputs, project maintenance and sustainability, and project impact questions. The individual results of the initial coding were compared, with discussion regarding clarifying the codebook items and descriptions, and the addition of a couple items that were not easily coded with the preliminary codebook. The revised codebook was used again by the coders to re-code the same proposals after one-week of time since the initial coding had elapsed. Cohen's kappa was calculated to determine the inter-coder reliability with the final codebook. At the individual codebook element level, the kappa was 0.55, indicating moderate consistency between coders. At the grouped codebook level (using the groups identified in section 4.B), the kappa was 0.82, indicating excellent consistency.

D. Proposal coding and analysis

To complete the analysis, the two coders used the validated codebook to identify various assessment methods in the EPICS in IEEE proposals. Including the proposals used for the codebook validation, a total of 93 proposals were analyzed. Beyond the initial subset of 10 proposals selected for codebook testing, the remaining funded proposals were split between the two coders, and additional not-funded proposals to reach approximately 50 proposals each for analysis were assigned. The not-funded proposals were ordered alphabetically based on project title, with the first coder starting at alphabetically at "A" and the second coder continuing alphabetically from their start point of "K". A total of 93 proposals were coded for analysis between the two coders.

Results of the individual coding were compiled into a single document. The number and proportion of proposals with each type of positive coded items were compared between funded and not-funded proposals. The two-sided two-sample Z proportion test was used to determine statistical significance between the funded and not-funded proposals using the hypothesis, with the null hypothesis proposing no difference between the proportion of codebook entries between the funded and non-funded proposal subsets:

$$H_0\colon\ p_0 - p_1 = 0$$

Due to a large number of codebook items having only a few positive codebook entries, many of the individual codebook items could not be analyzed statistically due to not meeting required test condition sizes. To complete the analysis, individual codebook entries were grouped into the five categories shown in the codebook creation section of the paper. That is, any proposal that had a positive codebook value in at least one codebook item within the category was assigned a "1" for the category. Similar analysis compared the funded vs not-funded proposals with the broader categories.

V. Results

Table II shows the counts, percentage, and p-value of the impact assessment categories. The categories where the test score suggests statistically significant differences in the populations includes the pre-deployment assessment category and the impact metrics category. At the individual test level, most entries did not have large enough counts to be eligible for statistical testing. Of those that did, individual items with statically significant p-values include "*performance metrics from testing or usability studies, including number of users*" (p-value 4E-05), and "*quantitative/measurable impact suggested, but no plan*" (p-value 0.0199).

TABLE II: COMPARISON OF CODEBOOK ELEMENTS PRESENT IN FUNDED AND NOT FUNDED PROPOSALS

	Pre-Deployment Assessment	**Community Engagement**	**Post-Deployment Assessment**	**Impact Metrics**	**Technical Performance**
# Funded Proposals (22)	6	15	5	18	9
% of Funded Proposals	27.3%	68.2%	22.7%	81.8%	40.9%
# Not Funded Proposals (71)	5	43	9	27	45
% of Not Funded Proposals	7.0%	60.6%	12.7%	38.0%	63.4%
p-value	**0.0102**	0.5193	0.2494	**0.0003**	0.0620

VI. DISCUSSION

Two overall categories and two distinct codebook items had statistically significant differences between the funded and non-funded proposals for the coded occurrence of various impact assessment methods. This supports the idea that the EPICS in IEEE rubric category of impact assessment is relevant when differentiating between proposals that will receive funding and those that will not. Anecdotally, EPICS in IEEE reviewers have told the authors they rarely select proposals for funding that do include significant community impact assessment plans. Likely, those submitters that are include a strong impact assessment plan are also including other relevant information that EPICS in IEEE committee members and reviewers look for according to the rubric categories.

A. Examples of impact assessment within proposals

Best practices for community impact assessment are demonstrated through the literature, but in general very few EPICS in IEEE proposals had a significant number of items coded, even those that were funded.

Of those projects that included community impact assessment, the sections were often vague. Some proposals would identify an impact goal without specifying how it would be measured. As an example, one proposal noted:

> *"The project's success will be determined by the number of lives saved and injuries prevented due to early warnings and effective [project technology]…"*

This proposal identified specific long-term quantitative values that could be obtained to compare the project impact to the current situation, but did not provide baseline numbers to compare to, nor describe how they would obtain the desired values (no clear timeline or methods).

One funded proposal included a representative of the partner organization on the design team, planned to host a demonstration event to attract potential users, and defined success in terms of the number of users that would adopt or use the prototypes. A selection from their Project Impact statement is:

> *"Project's Success Criteria: … Firstly, we aim to establish the prototype as a central component in [the partner organization's] research facilities. …Moreover, we are working on the development of six prototypes. Our goal is for these prototypes to be adopted by [users] across the region, with their usage adapted to real working environment. These prototypes should remain operational for a year while contributing to an increase in average productivity. …"*

Another funded proposal provided an example of two-way community engagement, and clear identification of users and stakeholders. A selection from their Project Description regarding scope is:

> *"Pilot Study: work with our partners at [partner organization] and engage … managers, volunteers, citizen scientists, and students in … After developing the … model, … stakeholders will be consulted to discuss feasible design, practicality, and relevance. Stakeholders include …"*

Proposals were more likely to include mention of technical success than community impact assessment as a measure of impact. It is possible that the proposals focus on technical success because the project was being proposed within a classroom environment where student learning of technical outcomes is a priority, or because most traditional engineering students are not trained on community impact as a critical measure of project success.

B. Lack of significant community engageement

Many of the project proposals had limited community engagement, with the student teams only providing information to the community. A two-way engagement throughout the design process (in planning, in prototyping, during deployment, and after deployment) is needed with potential users and stakeholders providing feedback. Important questions include, "Do the users want the technical solution as proposed, does the design provide the right mix of features, and what technical benchmarks are needed for significant impact?"

VII. Best practices and Recommendations

In general, it appears many student service-learning proposals failed to identify community impact assessment methods when describing and submitting their EPICS in IEEE proposals. This trend was similarly seen by the lack of community impact methods addressed in the peer-reviewed papers presented at the GTHC. In order to increase the likelihood that engineering projects consider impact from the start, a more conscious effort needs to be made to train students about community impact. Faculty or facilitators of service learning or community engaged learning can encourage students to consider the broader impacts of their project early in the planning process. Mattson et al. created a list of 55 question prompts that encourage students to consider the social impacts of engineered products [30]. Use of these prompts encouraged more event consideration of social impacts across a wide variety of areas than the initial subsets identified by students.

Service-learning proposals will be strengthened by giving strong development to both technical design and to community considerations. Project teams have opportunities to engage the community throughout the project term as parallel activities with the technical aspects. The categories of assessment strategies as shown in Appendix 2 give insight into how such plans can be structured. In addition, reviewers have noted favorably the proposals that have significant interactions with the community and users before proposal submission. These proposals tend to be better aligned with community needs and to offer improved long-term sustainability. Overall, student teams should regard the users and stakeholders as active participants in the work. A meaningful assessment plan will reflect this perspective. Long-term quantitative assessment such as that given in Paddock [15] may not be possible for most EPICS in IEEE proposals, but some form of metrics should address how well humanitarian/community impact is achieved.

One additional observation made by the EPICS in IEEE committee members to the authors were that most of the proposals tended to over-estimate the number of people that would be directly impacted by a project in both the short-term and long-term. This is often seen with a mismatch between a small number of prototypes that can only be used by a small number of individuals, but predict impact in the thousands. The authors suggest that future submitters to EPICS in IEEE and those in other humanitarian program critically reflect on the scope of impact feasible based on the resources and scope of the proposed project.

VIII. Summary

Over 90 projects in the EPICS in IEEE program were examined for their assessment strategies. These strategies are recognized by the EPICS in IEEE committee as essential for the program to accomplish its service-learning and community-impact goals. Proposals selected for funding tended to have stronger assessment elements especially in the areas of community engagement and impact metrics. Funded proposals tend to treat the design process and the assessment process as parallel activities. However, the assessment strategies tended to be weaker elements of the overall proposals, certainly weaker than the student learning and design innovation elements. The opportunity for student teams to develop more robust assessment is great. Related training and best practice examples can enhance the service-learning experience and lead to projects with greater overall impact.

These student proposals tended to focus on student roles and technical tasks with lesser consideration given to the community users and stakeholders. This work identified the following categories of assessment-related strategies – pre-deployment community feedback, community engagement during development, post-deployment community feedback, impact metrics, and measures of technical performance. Community engagement was a part of some EPICS in IEEE proposals, but not all. The type of community engagement and frequency of community engagement can strengthen the likelihood of success when deploying the project with the community. Every proposal may not need all of these elements, but proposals with a well-developed assessment plan will maximize the chances for truly meeting community needs.

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APPENDICES

Appendix 1. Impact Assessment Portion of the Rubric for Proposal Review

Impact Assessment: Does the proposal have reasonable impact numbers and an assessment plan?	
4-Exceeds Expectations The project proposal includes realistic short-term and long-tern impact numbers, and there is an achievable plan to collect impact data during and after the project.	3-Meets Expectations The project proposal includes somewhat-realistic short-term and long-term impact numbers, and there is a plan to collect impact data during and after the project.
2-Approaches Expectations The project proposal's numbers for short-term and long-term impact do not seem appropriate for the project scope. The assessment plan to collect data is weak.	1-Does not meet Expectations The project proposal has unrealistic project impact numbers and an unrealistic or not-included assessment plan.

Appendix 2. Codebook Items and Descriptions

Codebook category	**Codebook Item and Descriptions**
Pre-Deployment Assessment	Pre-Survey with Users
	Pre-Survey with Secondary Stakeholders
	Pre-Interviews with Potential Users
	Pre-Interviews with Secondary Stakeholders
	Pre-Focus Group
Community Engagement	Community member as a significant part of the design team/process
	Community training or orientation session about the project after deployment
	Collecting general community feedback (no method specified) intended for future iterations
Post-Deployment Assessment	Post-Interviews with Users
	Post-Interviews with Secondary Stakeholders
	Post-Surveys with Users
	Post-Surveys with Secondary Stakeholders
	Post-Focus Groups
Impact Metrics	Performance metrics from testing or usability studies (includes # of users)
	Quantitative/measurable impact (i.e. resource reduction) with a plan (i.e. baseline already)
	Quantitative/measurable impact suggested, but no plan
Technical Performance	Anything measuring technical device performance (qualitative, no # identified)
	Anything measuring technical device performance (quantitative comparisons to benchmarks)