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## **Challenges in developing collaborative interdisciplinary research between gastroenterologists and engineers**

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## **Challenges in developing collaborative interdisciplinary research between gastroenterologists and engineers**

The role of technology in healthcare is rapidly evolving. However, it can be argued that gastroenterology has not kept pace with other medical fields due to the multifaceted needs of this speciality and other issues. Innovation in healthcare technology increasingly requires interdisciplinary collaboration between engineers and clinicians. Nevertheless, working in such an interdisciplinary environment can be challenging due to factors such as working culture, communication and difference in priorities. We surveyed the views of clinicians specialising in gastroenterology and engineers on interdisciplinary health research. The 21 respondents expressed a range of opinions on the perceived benefits and challenges of interdisciplinary collaboration. Though engineers and clinicians recognised its advantages, they expressed a need for further improvement. However, engineers and clinicians differed in how best this could be achieved. The results of this survey are discussed with reference to the literature on interdisciplinary collaboration.

Keywords: interdisciplinary research; gastroenterology; biomedical engineering; collaboration; healthcare technology

### **Introduction**

Successful development and improvement of healthcare technology is a complex problem, requiring contributions from different disciplines such as medicine and engineering. Collaboration between these disciplines to achieve success can take place in several ways, with interdisciplinary and multidisciplinary approaches being widely reported. Interdisciplinary research is defined as “the contribution and collaboration between researchers from different disciplines, considering the whole system design requirements and providing an integrated solution to a common problem, overlapping disciplinary boundaries, generating new common methods, knowledge or perspectives” [1]. This approach contrasts with the simpler multidisciplinary situation where researchers from different disciplines work together to solve a problem without crossing

their respective disciplinary boundaries [1]. However, a mutually beneficial collaboration between different disciplines is often a complex process due to a multiplicity of factors including communication, distance and culture [2], [3]. In the face of the complex issues underlying interdisciplinary collaboration, much research has been carried out to understand and improve it [4], [5].

The increasing importance of interdisciplinary research is reflected by the growing body of literature examining the advantages and disadvantages of collaborations between clinicians and other fields such as life sciences [6] and social sciences [7]. However, there has been little examination of the perceived benefits and challenges of interdisciplinary research involving clinicians and engineers, even though engineering plays an essential role in research and development of medical devices. This paper aims to address this gap in understanding in the field of gastroenterology in particular.

The essential nature of the development and use of technology in gastroenterology is evidenced by modern endoscopy devices, a class of instruments which has made all parts of the gastrointestinal tract accessible for diagnosis [8]. However, the pace of innovation in gastroenterology has not kept up with other fields such as cardiology and orthopaedics for various reasons [9]. This situation is unexpected since it can be argued that the potential impact of technology on gastroenterology has yet to be realised fully. However, the gastroenterology community has relatively complex needs that require interdisciplinary solutions and contribute to the lack of progress. This example epitomises the difficulties encountered in translational medical research, where developments experience difficulty moving from a controlled laboratory environment into the more complex clinical environment [10], [11]. The skills, experience and knowledge of various professions applied in an

interdisciplinary way are vital to ensure that any such developments can be successfully implemented.

As a contribution towards progress in this area, this paper presents results from a survey of the attitudes and perspectives towards interdisciplinary research of participants at a minimally invasive endoscopy workshop, which included both engineers and specialists in gastrointestinal medicine and surgery. The results of this survey are discussed with reference to the literature on interdisciplinary collaboration in order to identify common challenges in research collaboration between clinicians and engineers. This paper also proposes solutions to these challenges based on the responses and experiences of survey participants.

## **Method**

A survey was sent out to 60 delegates at a Workshop on Minimally Invasive Endoscopy, attended by both engineers and clinicians on 6<sup>th</sup> March 2017 in Edinburgh, UK. The clinicians were primarily specialists in gastrointestinal medicine and surgery. The survey consisted of three Likert-scale questions and six semi-structured questions. The questions were focussed mostly on attitudes and experiences towards interdisciplinary research. We did not define what was meant by interdisciplinary research in the survey so as to not bias the responses.

A thematic content analysis was used to determine the relative strength of various patterns within the data. Multiple themes were identified amongst the answers received for each question. These themes were used to categorise responses expressed by the participants regarding interdisciplinary collaboration. Each survey response was examined using these themes to identify clusters of shared opinion.

## **Results**

[Table 1 near here]

[Table 2 near here]

[Table 3 near here]

Of the 60 attendees, 21 (35%) replied to the survey, with a near balance between engineers and clinicians as shown in Table 1. All of the survey participants expressed a favourable view of interdisciplinary research as shown from the results in Tables 2 and 3, recognising the added value of such collaborations to research (100% agreed) and its necessity for research success (100% agreed).

All of the clinicians surveyed were in favour of interdisciplinary collaboration with engineers as seen in Table 2. Arguments against interdisciplinary research previously reported by clinicians, such as top-down imposition by policymakers and curtailing of academic freedom [6] were not reflected in our survey. Instead, many of the clinicians surveyed recognised the benefits of working with engineers. The responses made by the participants throughout the survey showed that they were knowledgeable about the many challenges encountered when working with other disciplines, suggesting previous experience of this type of collaboration that may have contributed to their positive attitude.

### ***Perception of benefits to interdisciplinary collaboration***

Participants were asked their opinions regarding the benefits of interdisciplinary collaboration between clinicians and engineers/scientists. The answers given were analysed, and various recurring themes were identified and labelled “Academic Impact”, “Clinical Impact”, “Commercialisation Opportunities”, “Knowledge Exchange” (KE) and “Technical Innovation”.

“Academic Impact”, in this study, refers to those answers that mentioned peer-reviewed publications as a useful output, whereas “Clinical Impact” refers to the application of products for improved practice or to meet an unmet clinical need. “Commercialisation Opportunities” refers to those answers that mention bringing a product to market. The KE theme defines the transfer of ideas and skills, which may help develop possible solutions. “Technical Innovation” refers to the development of the underlying technology, which may not necessarily lead to better products for improved practice or to meet an unmet clinical need.

[Figure 1 near here]

The clinicians and engineers surveyed both agreed that clinical impact was the primary benefit of clinician - engineer collaboration as shown in Figure. 1. However, clinicians believed that knowledge exchange was the second most important benefit while technical innovation was found to be the second most important benefit for engineers.

### ***Perception of challenges associated with interdisciplinary collaboration***

[Figure 2 near here]

Those surveyed were asked to define the most significant risks affecting successful interdisciplinary research between clinicians and engineers, in their opinion. The answers were analysed and each challenge was attributed to one or more common themes. These themes were called “Commercialisation”, “Communication”, “Culture”, “Funding”, “Interaction”, “Relationships” and “Vision”. The variation in the priority of each of these themes across all those surveyed are shown in Figure. 2.

“Commercialisation” refers to doubts that the impact of the research could be limited and that solutions generated might not have market pull. “Communication” was

the most frequently encountered theme, defined as the ability to accurately express oneself with clarity to practitioners of other disciplines. “Culture” relates to the different working styles of the two disciplines; “Funding” relates to the challenges of securing financial support due to the interdisciplinary nature of a project and “Interaction” refers to the lack of regular contacts. The “Relationships” theme defines personality conflicts due to ego and lack of respect between disciplines. “Vision” reflects the possibility that clinicians and engineers may work towards separate goals without shared priorities.

Many of those surveyed cited “Communication” as the primary challenge associated with interdisciplinary collaboration. This is unsurprising, as communication has repeatedly been recognised as an essential factor in successful interdisciplinary research [4]. An impediment to interdisciplinary communication is the development of a monodisciplinary dialect, complete with specific acronyms, terminology and jargon due to years of specialised training. Such dialects are often perplexing to those outside the field, leading to difficulty expressing oneself, explaining the complicated subject matter, or following the published literature in other domains [12]. Effective and regular communication is critical to transcend those disciplinary boundaries (a) to develop solutions to the problems being investigated, (b) to build upon the shared vision of the project, and (c) to develop a mutually respectful working relationship and sense of team identity [5][13] [14].

“Vision” was the second highest risk associated with interdisciplinary collaboration for those surveyed. This refers to the lack of an agreed or shared view of the aims of the project. A shared project vision, along with associated goals, is believed to enhance team performance by stimulating communication and cooperation and improving productivity [13]. The process to develop a shared vision can be time-consuming, with one barrier being lack of familiarity with the monodisciplinary dialects

of the various disciplines involved [14]. The importance of vision matches some of the responses of the participants about why a lack of vision was detrimental to interdisciplinary collaboration. Participants cited reasons such as failure of explicit communication relating to the needs of clinicians or the technical possibilities available to engineers. Some also cited the different motivations and priorities of team members as other factors in the failure of collaboration: one participant mentioned engineers developing a new feature merely to overcome technological limitations without this being of use to clinicians, i.e. a technology-push approach to collaboration as opposed to a clinical needs-based approach [15].

Disciplinary culture exists in most fields, formed through participants' undergraduate and postgraduate curricula, common readership of academic texts, and other factors [14]. Differences in disciplinary culture were not a primary concern for many of those surveyed. This may be attributed to the fact that those surveyed were attendees at an interdisciplinary workshop and may therefore be expected already to have been comfortable with working across different disciplinary cultures.

A good relationship between the different disciplinary representatives was also stated as necessary for a sustainable collaboration. This corroborates findings from previous studies that highlighted the importance of trust, reputation [16], past working experience [17] and previous interdepartmental collaboration [18]. Furthermore, prior experience of collaboration between researchers ensures familiarity with one another's habits and preferences, which aid in establishing a comfortable working environment [19], [20].

It has been shown in one study [21] that a previously established good working relationship between collaborators could reduce the negative impact of distance and difference of disciplines on the successful outcomes of a collaboration. However, the

lack of past working relationships, and also reputation, does not necessarily disadvantage early career researchers or those who wish particularly to enter into such a collaboration. Repeated collaborations between the same partners from different disciplines have been shown to reduce the probability of innovative research due to the homogenization of their pools of knowledge [22]. Therefore, collaborations that incorporate new partners with new perspectives can lead to more innovative research outcomes with more impact [23].

### ***Current opinions on channels of interdisciplinary communication***

[Figure 3 near here]

Participants were asked about their experiences of existing channels of communication between clinicians and engineers. The nature of these channels was not specified. The statements received were categorised as either being positive, neutral or negative based on their content. The majority of the answers suggested a negative opinion of such channels. As shown in Figure. 3, the responses of the clinicians only showed a slightly favourable opinion of 45% compared to the unfavourable opinion of 36% and neutral view of 18%. Engineers predominantly viewed the current channels of communication negatively, with 75% of those surveyed having a negative opinion, 12.5% positive and 12.5% neutral.

Several of those surveyed suggested that the current channels of communication lack effectiveness due to an absence of awareness of their existence amongst the wider community. Even when existing channels of communication were known, they were found to be unsystematic, poorly developed and monodisciplinary. Some participants expressed a view that there are limitations to the effectiveness of these channels in

fostering collaboration, with the initiative of the individuals involved required ultimately to form a collaboration.

### ***Proposed solutions for improved interdisciplinary collaboration***

[Table 4 near here]

Participants were asked if interdisciplinary training schemes would be beneficial in fostering better communication between clinicians and engineers/scientists. The format of this interdisciplinary training scheme was not defined. The results, shown in Table 4, demonstrate that there is widespread support for such an initiative from engineers and clinicians.

[Figure 4 near here]

Those surveyed were asked for ways to improve interdisciplinary research between the two disciplines. The answers received were clustered into various themes to identify underlying trends. As shown in Figure. 4, there were differences between clinicians and engineers regarding the best method to improve interdisciplinary collaboration. The results showed that clinicians primarily favoured regular events or fora for KE and networking as the best approach, whereas engineers thought an interdisciplinary masters level education was the best method to improve collaboration. This difference in approach may be due to factors such as limited clinician time availability. A previous study of surgeons highlighted that, as their time and resources are increasingly limited, they are using events such as workshops, conferences and other events to forge the social networks that can lead to research collaboration [24]. The same study also showed that surgeons value the importance of these social networks as they now generate an increasing share of research outcomes.

### *Education*

Those that mentioned education suggested combined research degrees such as interdisciplinary Masters-level courses as suitable means of achieving improved collaboration. The increased recognition of the role of technology within medicine by some clinicians [25], [26] has resulted in the development of several engineering - clinician courses in the USA [27]–[29]. However, medical education in the UK has yet to follow this example. Additionally, biomedical engineering education in the USA has embedded clinical collaboration and needs-based technology development through clinical immersion of students [30]–[33] and the utilisation of global health challenges in various courses [34], [35].

### *Geographical proximity*

A few participants mentioned that close geographical proximity or exchange of staff as being a factor in improved interdisciplinary collaboration. This closeness facilitates a higher frequency of formal and informal face-to-face interactions, which have been demonstrated to strengthen collaborative relationships[4], leading to increased KE [36] as well as improving communication and trust [5]. In some cases, a team composed of geographically-diverse members may be unavoidable due to the need for expertise not found locally. However, a group constituted with members from different institutions may find that local obligations, such as teaching or other research projects, may draw their time and attention away from more physically distant concerns [21].

Several studies have highlighted the use of regular face-to-face meetings and retreats or electronic communication technology to enhance interdisciplinary collaboration in spatially-distributed teams. The lack of sustained coordination of these efforts can result in reduced project outcomes for geographically dispersed partnerships

[23]. Additionally, studies recommended in-person contact before subsequent remote collaborations between new partners to generate trust amongst team members [37].

### *Best practice*

Participants were asked what they considered positive and negative practices based on their experience of research collaborations between engineers and clinicians. A plurality (42%) of examples of good practice involved regular and clear communication with a well-defined and shared vocabulary of discipline-specific terms as well as a shared vision for the project. The responses also included statements supporting the idea that regular, respectful bidirectional dialogue between clinicians and engineers at all stages of the project was vital for successful collaborations, ensuring clinically appropriate deliverables. This involved a regular dialogue with clinicians explicitly highlighting their needs and engineers informing clinicians of the technical feasibility of these needs.

### *Bad practice*

Poor communication (33.3%), geographical distance (4.7%), conflict over intellectual property (9.5%) and competing visions or priorities (14.2%) for the project were examples of bad practice experienced by those surveyed, as expected from previous answers. An example of the danger of poor communication leading to poor collaborative practice came from an engineer involved in a project where clinicians advocated a technological solution to the clinical problem for the engineers to implement. This can lead to frustration as the solution is proven to be unsuitable or unworkable due to clinicians' lack of awareness of technical limitations. It also suggests a hierarchy, with the engineers perceived to be working for the clinicians as opposed to an equal partnership. Conversely, clinicians spoke of engineers working independently

of clinical advice after the problem had been communicated, without further consultation. This led to the production of devices that were not clinically relevant or useful.

Both of these examples highlight the importance of on-going, reciprocal communication and the need to respect the collaborative partnership. They both highlight potential pitfalls in developing a technical solution to a clinical need and underscore the fact that the complexity of medical device engineering requires the involvement of all disciplines in the decision-making process [38].

## **Conclusion**

Our results from a survey of a total of 21 engineers and clinicians highlights the pitfalls of interdisciplinary collaboration based on the experiences of the participants and points the way to how collaboration can be improved among healthcare professionals and engineers.

One recommendation from this survey is that a regular forum for communication between clinicians and engineers should be established. This forum should provide a means of formal knowledge exchange in which engineers are informed of clinical challenges and relevant technologies are highlighted to clinicians. This forum should have a social element to strengthen the research networks of established clinicians while also providing a means for early career researchers to build the relationships that are important for their futures. This forum should be well advertised amongst the relevant engineering and clinical communities.

Improving interdisciplinary collaboration between engineers and gastroenterologists, as well as the broader clinical community is of increasing importance due to the growing reliance of medicine on new and emerging technologies

as well as the recognition of the importance of healthcare innovation to economic development.

Our study has limitations due to the sample size and the focus on the gastroendoscopic clinical subdiscipline. Additionally, the targeted audience was potentially biased as the attendance of the participants at the event suggested an existing interest and previous experience in interdisciplinary research. Further investigation of the views of a more extensive population of engineers and clinicians is required to validate the broader applicability of these initial results. Nevertheless, they match conclusions drawn from the literature and make an important contribution to the understanding of contemporary collaborative activity.

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Table 1. Demographic characteristics of survey participants

Characteristic	Engineer (n=9)	Clinician (n=12)	Total (n=21)
Median years experience	15	20	16.5

Table 2. Range of viewpoints as to whether interdisciplinary collaboration adds value to research

Interdisciplinary collaboration adds value to research			
	Engineer (n=9)	Clinician (n=12)	Total (n=21)
Strongly Agree	7	12	19
Agree	2	0	2
Neutral	0	0	0
Disagree	0	0	0
Strongly Disagree	0	0	0

Table 3. Range of viewpoints as to whether interdisciplinary collaboration is necessary to success

Collaborative research is necessary to success			
	Engineer (n=9)	Clinician (n=12)	Total (n=21)
Strongly Agree	6	12	18
Agree	3	0	3
Neutral	0	0	0
Disagree	0	0	0
Strongly Disagree	0	0	0

Table 4. Range of viewpoints on the benefits of interdisciplinary training scheme for fostering better communication between clinicians and engineers/scientists

Interdisciplinary training schemes would be beneficial in terms of fostering better communication between clinicians and engineers/scientists.			
	Engineer (n=9)	Clinician (n=12)	Total (n=21)
Strongly agree	6	7	13
Agree	2	4	6
Neutral	1	1	2
Disagree	0	0	0
Strongly Disagree	0	0	0

Figure 1. Importance of various benefits associated with interdisciplinary research between clinicians and engineers

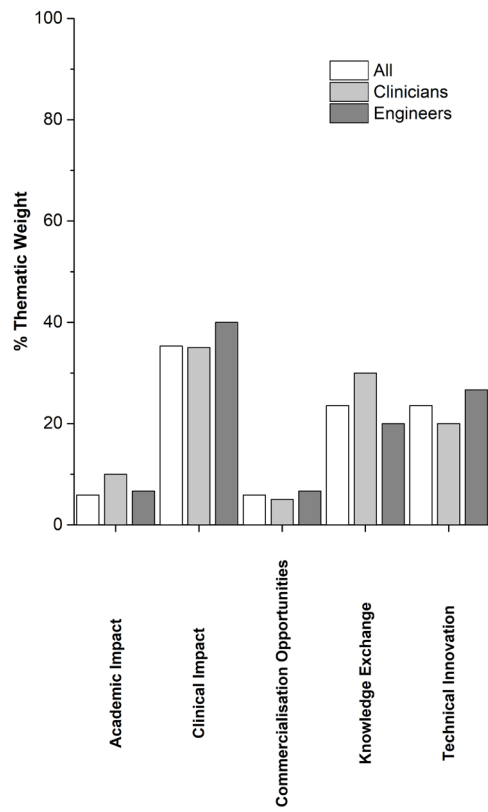


Figure 2. Importance of various risks associated with interdisciplinary research between clinicians and engineers

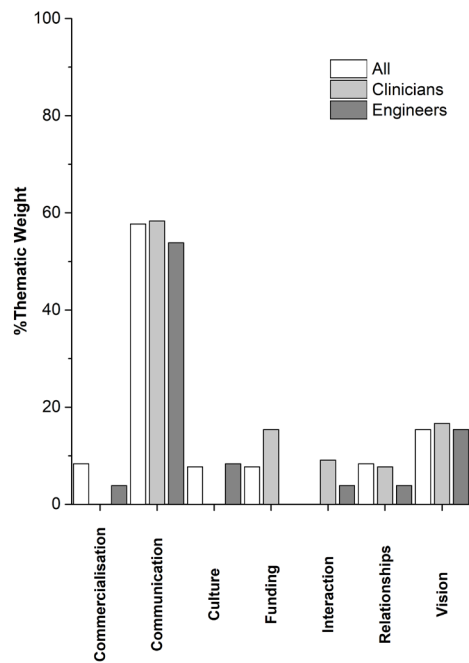


Figure 3. Opinions of those surveyed on current channels available for communication in interdisciplinary collaboration

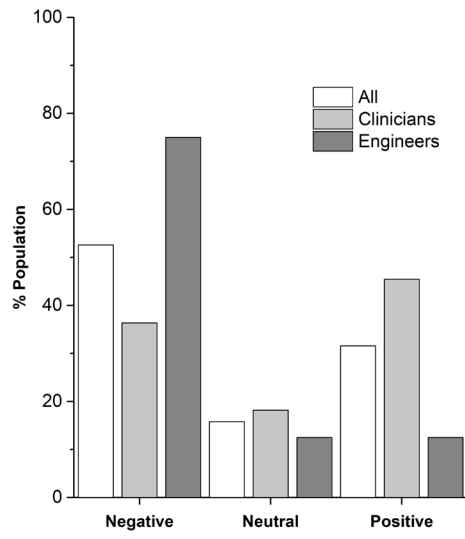


Figure 4. Popularity of solutions proposed by those surveyed to improve interdisciplinary communication

