An Exploratory Study of Scientists' Perceptions of Design and Designers

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Abstract

As part of a wider empirical study in to the potential role of industrial design in scientific research, a series of semi-structured interviews were conducted with scientists to understand how their perceptions of design and designers might influence collaboration.

This paper reports that scientists without prior experience of working with designers may be unclear as to their skills and areas of expertise, and may subsequently be missing out on collaborative opportunities.

Scientists perceive a greater possible impact on applied research through engagement of professional design skills. It was revealed that design interventions could be suitable for many scientists as their range of research activities is likely to include both basic and applied research. Opportunities were identified for designers to play a role in scientific research, especially with issues relating to communication.

Keywords

collaboration; multidisciplinary; industrial design; perception.

There is potential for industrial design to play an important role in the advancement of science and technology as highlighted by Lord Sainsbury in his 2007 Review of Science and Innovation. "Evidence suggests that the use of design helps scientists to develop commercial applications for their work while it is still at a research stage or at the outset of technology" (Sainsbury 2007, p151). Indeed there is substantial evidence of the value of industrial design in the development of new technology in industry (e.g. Kotler & Rath 1984, Lorenz 1994, Black & Baker 1987, Roy 1999, Gemser 2001, Hertenstein et al 2001). This work concludes that industrial designers can help to commercialise technology by becoming involved earlier in the development process. Despite this, surprisingly little academic work has been carried out looking at the role that industrial design might play in scientific research, from which much technology originates. Existing studies in this area are anecdotal and lack first hand evidence of the factors influencing collaboration:

- Chris Rust identified opportunities and barriers for collaborative work between designers and scientists, and outlined 'tentative principles' for designers in collaborative research (Chris Rust 2004 and 2007).
- The MIT media lab provides an environment for 'exploring basic research and applications at the intersection of computing and the arts' (http://www.media.mit.edu/research/ accessed Sep 2007). Similarly, there are a number of multinational firms who have experience of operating these 'sand-pit' environments; e.g. Microsoft, Bell Labs and Google.
- A pilot scheme was supported by the UK Design Council in partnership with the EPSRC and UCL Ventures, to bring design consultancies into scientific research (Design Council 2006).
- A UK Design Council scheme in partnership with Maddison Design and Oxford University brought design consultancies into university technology transfer offices (Design Council 2009).

To address the current gap in empirical research in this area, a study was set up at Cambridge University in which designers worked collaboratively with scientists in supporting their research activities. In addition to exploring the potential role of industrial design in scientific research, this study set out to understand how contingent factors such as the scientific discipline, the status of the research and the type of design intervention would influence collaboration. This paper presents the findings of a series of preliminary interviews conducted with scientists as part of this study, to gain insight into these issues.

The objectives of the interviews were:

1. To explore the scientists' perceptions of the status of their research in terms of how applied it is and at what stage of development it is.
2. To explore scientists' perceptions of design and designers and to understand how these perceptions may influence collaborative work between designers and scientists.
3. To gain scientists' views on the possible roles designers might play in supporting their research activities.

Although the focus of the study was on industrial design, the scientists were asked their views about design in the broader sense so as to capture their views on a wider range of issues.

The paper begins with a description of how a literature review influenced the design of an interview to achieve the above objectives. It then outlines the interview procedure before presenting and discussing the results. The paper concludes with implications for future study.

Literature Review

Classification of Scientific Research

Recognising that 'science' covers a wide range of disciplines and research activities, and that the role of design will likely depend on the context of the research, a method of classification of scientific research is required.

Pierce's outline classification of science illustrates the wide range of activities that employ a scientific method (Vehkavaara 2001). It was decided that participants from this study would be selected from a wide range of scientific disciplines including the physical (e.g. physics, chemistry, and biology), applied (e.g. engineering and medicine), formal (e.g. mathematics) and social (e.g. psychology) sciences.

Linear models have been applied to scientific and technological development in the form of Applied Science Readiness Levels (ASRLs) and Technology Readiness Levels (TRLs), which were developed by NASA to manage their R&D programmes (Millis 2005 p13, DoD 2002 pp204-205,). These models suggest that scientific research can be classified by developmental stages.

It is also important to consider the motivation for scientific research. Traditionally, research has been categorised as either "basic" or "applied", the former being focused on improving understanding of fundamental principles, and the latter focused on considerations of use. Stokes suggests that there is a third category of research motivated by both the pursuit of understanding principles and their application, which he called "use-inspired basic research" (Stokes 1997, p73).

Based upon these views, a model of scientific research was developed to position scientists' work both in terms of the stage of development and the degree to which it is applied. The model shown in figure 1 shares Stokes's motivations for scientific research, and anticipates definable stages of development similar to TRLs.

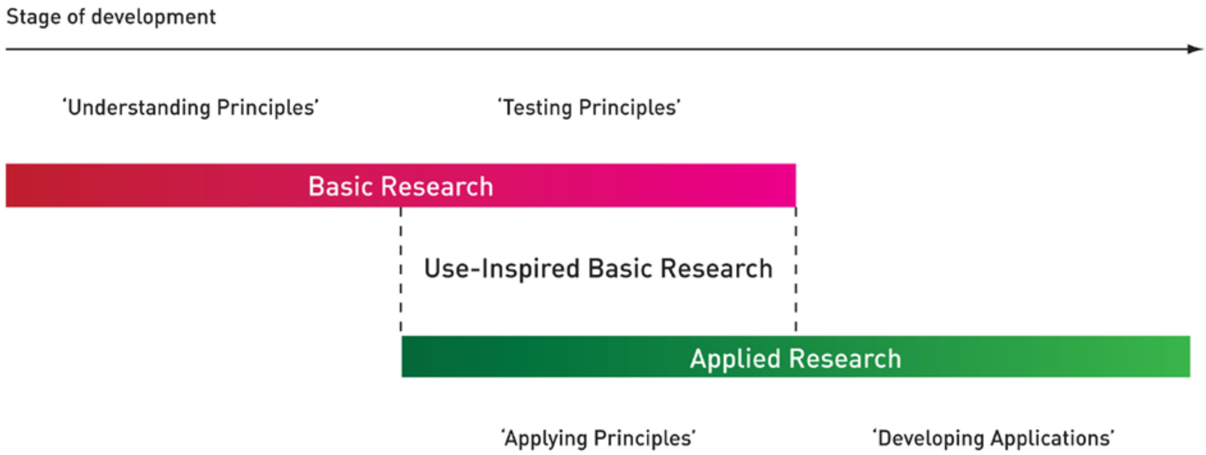

Figure 1 Model of Scientific Research

Designer Characteristics

In order to meet the second objective of the interviews, a list of characteristics was developed which could be used to describe a designer. It was decided that these would be adapted from the Scottish Credit and Qualifications Framework's list of the main areas of learning for students enrolled in higher education (SCQF 2007). This was because these learning areas were developed to reflect what is expected of a professional designer by industry. These characteristics were "Skills", "Knowledge", "Ways of Thinking" and "Role in a Multidisciplinary Team".

Methodology

Potential interviewees were selected following meetings with the head of research at the university's engineering department and representatives from the Research Services Division. Of the 28 scientists contacted, 12 were interviewed, 4 declined, 6 did not respond and 6 sent delayed positive responses. Of those who declined, 2 cited time restrictions and 2 felt that design played a very limited role in their research. Table 1 gives a short description of each of the interviewees.

Scientist	Background
Engineer 1 [E1]	• Manages a research group with a portfolio of projects • Direct experience of collaborating with industrial designers on a research project
Engineer 2 [E2]	• Previously sat on the committee of research councils with an interest in funding design • Previously worked for a group of trusts, one of which funded a collaborative student project with designers and engineers
Physicist 1 [P1]	• Manages a research group • External designers had developed a Graphic User Interface for software his research team had created • Advocate of open innovation in software development and computational science
Physicist 2 [P2]	• No experience of working with designers • Married to a graphic designer
Engineer 3 [E3]	• Experience of working with companies that employ designers
Biochemist 1 [B1]	• Manages a research group • Multiple university spin-out companies • Experience of employing designers in later stages of product development
Clinical Scientists [C1, C2]	• Work in the clinical engineering department of a hospital • Bridge the gap between clinical departments and engineering designers • Experience of working with companies who employ designers • Mostly single patient or single institution use – little commercial activity
Engineer 4 [E4]	• Manages a research group • Previously managed a team including scientists, engineers and designers in industry • Experience in the commercialisation of products
Biochemist 2 [B2]	• Working on a collaborative project between biologists and chemical engineers • No experience of working with designers

Psychologist 1 [PSY1]	• Established a research group into multidisciplinary design • A member of the governing body of a leading art and design university
Material Scientist 1 [M1]	• Manages a research group • A member of a commission that funds student designers
Chemist [C1]	• Working on a collaborative project with an engineer and an architect • Married to an architect

Table 1 Interviewees

Interview Procedure

A semi structured interview was created which was split into three sections to meet the objectives stated in the introduction. The interviews lasted approximately an hour and were recorded for later transcription. The interviewees were informed that they would remain anonymous.

1. The scientists were first asked to describe their field of research, a current research project and their day-to-day research activities. They were asked to try and identify stages of development of their research and to comment on how applied they considered it to be. They were then presented with the model of scientific research developed in the literature review and asked to use it to try and position their work.
2. The scientists were then asked to describe what they understood by the word ‘design’. If they had experience of working with designers they were asked how successful the collaboration had been and how they overcame any difficulties that may have been encountered. They were encouraged to list the characteristics of a designer under the headings “Skills”, “Knowledge”, “Ways of Thinking” and “Role in a Multidisciplinary Team”.
3. Finally, the scientists were asked to identify any potential opportunities for the designer they had just described to support them in the research activities they had mentioned in the first part of the interview.

Interview Analysis

Soon after each interview, a summary document was written and emailed to each of the participants for comment. Two of the scientists requested that minor amendments be made to the interpretations. A synopsis of the interview summaries was written including partial transcription. The scientists’ answers to each of the questions were gathered and key themes were extracted for discussion.

Results

1. Scientists’ Perception of Their Research

All of the 8 scientists who attempted to position their work on the model of scientific research described it as including both basic and applied elements. This was because the scientists were often working on multiple projects at different stages of development with research teams from other universities. Thus, the map was less helpful in positioning the work of senior academics, who managed a complex portfolio of research. The map was more successful however in positioning individual research projects.

One scientist raised the point that what he considered applied research would be considered basic by others:

> *“In order to incorporate my work into the same map with other people’s you need to make it hierarchical...if you talk to a person who actually deals with the real world rather than the software, they would say that all of what I do is here [understanding]”* [P2].

Although some scientists made attempts at defining stages of development, no common threads emerged and some commented that the linear process suggested by the diagram was not representative of research practise:

"You can go in any direction... I mean a lot of pure scientists say to me 'well, you know what you're doing is you're taking our knowledge we've gained alright?, and all you're doing is applying it', this is a common view and it's total tosh I can tell you...We have one at the moment, a very specific application I'm interested in...we're going to have to generate some new fundamental knowledge...we've got about 5 or 6 approaches we're looking at, I don't know off hand which one is going to come up trumps" [B1].

Conclusions

- It is difficult to position the work of a particular scientist in terms of how applied it is, particularly when the scientist is engaged on multiple projects. However, it is possible to position individual projects, at a specific point in time
- It is difficult to define common stages of the scientific process, as much science is inherently iterative, with both application and the search for underlying principles occurring concurrently. This suggests that linear development models such as TRLs do not easily apply.
- Following the interviews, a new model of scientific research was constructed which more accurately reflected research being conducted at the university. The model shown in figure 2 illustrates how research, basic or applied, can give rise to applications, and how the development of applications can generate new scientific and technological research.

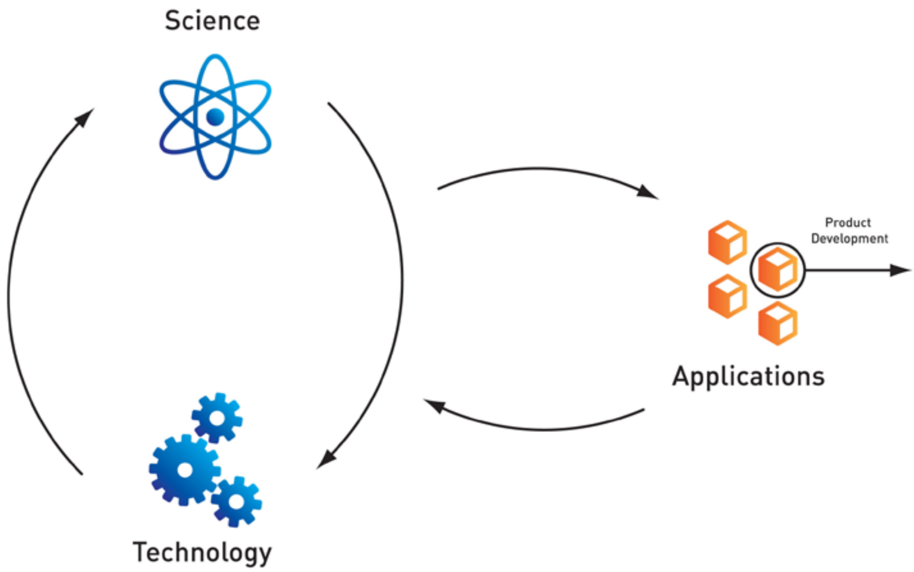

Figure 2 Model of scientific research post interviews

2a. Scientists' Perception of Design

The scientists said 'design' was something they did as part of their everyday work, for example engineering design, circuit design, experimental design, clinical design, survey design, alloy design or composite design.

Three quarters of the scientists interviewed mentioned at least one type of design profession in their answer. These were industrial, product, graphic, architecture and fashion. Those who did not mention specific disciplines said the following about design:

"You're talking about a different sort of design [to engineering design], the sort of design in which you bring somebody else along who thinks in terms of the shape and the looks and whether the general public like that colour or not" [E2].

"I suppose I would associate it [design] more with the arts and fashion" [P2].

"It [design] is a creative process... [A designer] is somebody who has a very visual way of looking at the world and who would work with materials and with people to...translate a vision into reality" [B2].

Some of the scientists commented on negative aspects of design:

"What I feel is a dangerous aspect...of design is the sort of making it look glitzy and pretty and calling that design, because I think it distorts what design is about..."The designer comes along with ideas that have no basis in the technology and maybe superimposes them on the design in a way that doesn't...benefit it and may actually detract from it...for me the idea of design is starting from the technical...and the sort of adding on has to be done very carefully" [E2].

"Product design is a bit more airy fairy really isn't it – it tends to be the fashion stylistic sort of approach...an industrial designer is just an engineer in my view" [E1].

"We rough out the ideas and it goes to a professional [designer] who tarts it up" [B1].

"Whether there is an aspect of design which maybe fulfilling the objective of art and beauty which degrades the fitness for purpose is actually very interesting, for example a very clever looking chair that's so uncomfortable you can hardly sit on it" [M1].

Some scientists had a more rounded view of design. More than half of the scientists described functionality, aesthetics and usability as being key aspects of design, with some also mentioning planning. Only one scientist used the word creativity in their description of design.

Conclusions

- The scientists interviewed recognise that design is an important everyday aspect of their work.
- There are fields of design closely linked with science e.g. experimental design, survey design. The scientists did not necessarily make clear distinctions between these and creative professions such as product, industrial, graphic and fashion design.
- Some of the scientist's initial perceptions of designers were as superficial stylists.
- These different perceptions are indicative of the difficulties in establishing consistent definitions of design.

2b. Experience of Working with Designers

5 of the 12 scientists had direct experience of collaborating with designers. A further 2 had indirect experience i.e. they may have worked with companies that employed designers. When asked what issues were encountered during this collaboration, communication was cited as the most common obstacle:

"Conveying the ideas and making sure we all understood what we wanted in terms of the design and the designer understood what was important to us. And that they had to convey to us what they thought was important...in terms of a getting the product in a package that could be used easily" [E1].

"Maybe visualisation is a tough one right? Or the language where I need a little bit of fill-in on some technical terms that might be utilised by him and in my case he would definitely need fill-in on the technical terms because he's not a chemist right?" [C1].

In both cases, these communication issues were overcome by maintaining frequent contact between the participants in the form of brainstorming sessions, meetings and workshops. Chemist 1 explained how problems encountered in interpreting 3D information were overcome by moving to 3D printing. He said "That helps put a lot of things into something I can physically touch and see and get an appreciation for".

Engineer 4 had experience managing a team including scientists and a designer. He said of the designer "He was very dogmatic, so he had very strong views about the importance of design and he would get very upset if people didn't get it or didn't think it was important". This became a problem with one of the designer's engineering colleagues.

Biochemist 1 saw his team as consisting of 'creative scientists'. He said "Creative scientists are few and far between, believe me...where they can see laterally as well as vertically...Most scientists think vertically...a lot of designers probably do think more laterally. If I look in this place in my experience over 30 years I'd probably put about 3 in that category [creative scientists]".

2c. Characteristics of a Designer

The scientists gave a very broad range of answers to this question. For example there were 30 different skills listed by the scientists.

Their answers showed large variation and depended very much on whether the scientist was describing the skills of a designer, themselves (in their capacity as a designer), both or neither. Of the 12 scientists interviewed, 6 described a 'designer', 2 described themselves, 2 described both and 2 did not annotate the graphic. Their answers also depended on the type of designer they had experience of, for example 3 scientists described industrial or product designers, 2 described graphic designers and 3 were not specific about the type of designer they were describing.

A selection of the most common and interesting answers is given in table 2. The numbers in brackets represent the number of scientists who mentioned each point:

Skills	**Knowledge**	**Thinking**	**Role**
Technical: Sketching (1) Model Making (1) CAD (2) Research (1) Engineering (2) Holding Focus Groups (1) Simulation (1) Technical Drawing (1) Project Management (1) Personal: Creativity (3) Communication (3) Observation (1) Patience (1) Listening (1) Restating (1)	Materials (5) Manufacturing Processes (4) Fashion/Styling (2) Graphics (1) Market (1) Technical (1) Regulations (1) Safety (1) Ethics (1) History of Design (1)	Lateral (3) Imaginative/ Artistic (2) Creative(1) Novel (1) Out of the box (1) Innovative (1) User Perspective (3) Curious (1) Holistic (1) Practical (1) Critical (1) Logical (1) Analytical (1) Unrealistic (1)	Integrator (3) Facilitator (1) Project Manager (1) End User Focus(1) Holistic (1) Commercial Focus(1) Inspire (1)

Table 2 Characteristics of designers according to scientists

Conclusions

- The scientists without experience of working with designers did not have a clear understanding of their characteristics.
- Those with experience had a more well-rounded view of designers, recognising their skills are wider than specific technical or materials knowledge.
- Materials and manufacturing processes knowledge were the most commonly recognised traits of designers

3. Scientists' Views on Potential Role of Design in Scientific Research

The scientists were generally sceptical about the role a designer could play during the early stages of scientific research. Biochemist 1 smirked at the question and said "I find it difficult to believe that they [designers] could contribute much round here [understanding] because you'd have to have a really detailed knowledge of the detailed science...You're better coming in somewhere around here [application].

> *"If you want design engagement in the scientific process, I don't see how the designer would have enough scientific knowledge to contribute to the discussion, so they may have divergent thinking, but only in terms of how to put bits and pieces of existing technology together. I don't see how they would be able to help in the brainstorming process of 'what are the scientific reasons why it's not working...I can see all these really strongly in the product development end"* [E4].

However some scientists didn't rule out the possible contribution of a designer in basic scientific research.

> *"How do you access the unknown unknowns, yes? The scientist isn't going to do it because it's unknown by definition yes? Anyone with different viewpoint...different ways of thinking about things, approaching problems can perhaps provide a route into those unknown unknowns. Every bit of science is suffering from this because every real issue in science at the moment is complex"* [P1].

> *"We have learnt so much, by working together between biology and engineering because you need to learn a different language...it's really opened up our horizons. That's why we are keen to work with other disciplines still because it just enriches your way of thinking so very much"* [B2]. When asked if she could see any potential benefits of working with designers, she replied, *"I don't know, it never does any harm to talk and you never know what comes out of it"*.

> *"Perhaps there is a design contribution in that area [scientific principles or understanding], I certainly haven't thought of it"* [E1].

Communication was identified as an important area in which designers could make a contribution.

> *"If someone can help me to see from the outside what the research looks like...that will help me putting my work across"* [P2].

> *"Most scientists have no understanding of what the general public out there actually understand, it's very important to relate it to them...a designer there would come in very well, say a poster for example"* [B1].

> *"I would put that [designers assisting with funding applications] down as marketing again, you're trying to get support from somebody for academic funding...I'm not used to getting money out of the EPSRC or the science funding bodies but they seem to like words...Using words alone is much less effective than words plus images, so I'd add pictures, images and video to the text"* [E4].

> *"Anything to do with public understanding and outreach, I fully agree [design input would be useful]...because that's not to do with functionality of a device it's t do with communication and visual appeal"* [B2].

Some other interesting areas of potential collaboration were identified

> *"Have we left ourselves with less of a development opportunity because we don't engage designers at a scientific level? I think that might be interesting if designers could spot ways of improving that process. And it's largely by not using Heath Robinson toolsets...by perhaps looking at the laboratory equipment, the methods of handling or moving or managing or conveying substances, the methods of testing...it could be design of the space, design of laboratory, design of the bench...that's where I would say the contribution could come in"* [E1].

> *"Lab space design, ha. That is true...thinking about how to lay things out – boy, that just never happens at the moment. It's a good point though"* [E4].

During the first 6 interviews, some of the scientists found it difficult to suggest ways in which a designer might be able to contribute to their research, so it was decided that a list of possible design engagements would be created to stimulate ideas:

- Application Exploration
- User/Market Research
- Concept Design
- Materials/Manufacturing Processes
- Engineering Design
- Prototyping
- 3D Visualisation
- 2D Communications
- User Interface Design
- Lab Space/Equipment Design
- Stimulate Interest/Excite
- Challenge Established Views

This list drew from the recommendations of the Design Council's pilot scheme in which design consultancies worked with scientific researchers (Design Council 2006). It also contains suggestions made by the first 6 interviewees, such as the design spaces and equipment.

Figure 3 Scaled design engagements

Figure 3 illustrates the effect of scaling the list of design engagements according to how many times they were selected by the scientists as playing a potential role in their research activities.

Assistance with communication was picked out by half of the scientists, closely followed by visualisation of products or concepts. Despite some of the scientists recognising that designers know about materials and manufacturing processes, only one of them said their research would benefit from support in this area. Engineer 4 suggested that designers would be of use in assisting with the production of technology 'demonstrators' to pitch an idea to investors or funding bodies. Two of the scientists' work was sufficiently close to market that the assistance they required was more akin to product development than scientific research.

> *"You get an awful lot of people...not far from where I'm sitting now, that actually come up with things...that you'd ever even conceive are going to be useful. And yet they'll spend ages and get research council money for it...They've got their pet project and they're looking for an application for it...There's a lot of pressure on people at the moment to get some sort of application...its government pressure, it's funding, pier group pressure"* [B1].

Talking about open innovation in computational science, physicist 1 commented "I see it [design] no longer divorced from the mainstream development, but sitting at all of the interfaces to make the fundamental science interact with the other bits of development.

Conclusions

- Some scientists perceived that there is scope for design engagement in their research activities, especially with issues relating to communication.
- However, the general consensus was that there isn't an immediately obvious contribution that design can make to basic research but some scientists would be open to exploring this further.

Implications

This research starts with the hypothesis that industrial designers might be able to make a contribution to the early stages of scientific research. Findings from this initial series of semi structured interviews provide some interesting insights into the factors which may affect collaboration between designers and scientists:

- Scientists' current knowledge of and perceptions of designers is limited, and where they have little prior experience, they are often sceptical about the potential for designers to make a positive impact on their research.
- Unless they have previous experience of working with designers, scientists are unlikely to be clear about designers' skills and areas of expertise, and some may perceive them as superficial stylists. Sharing knowledge about the characteristics of the two disciplines should open up more opportunities for collaboration.
- Design interventions could be suitable for many scientists as their range of research activities is likely to include basic and applied research
- Scientists perceive a greater possible impact on applied research through engagement of professional design skills.

Recognising these challenges, in order for design engagement to be successful, the following issues require consideration:

- It may be difficult for designers to persuade a scientific team or individual working on basic science to participate in a collaborative project, as the potential benefits are not immediately obvious. Offering to provide communication support could provide a possible avenue for entry into such a project.
- Designers should be sensitive to the fact that scientists participate in certain design activities as part of their everyday work e.g. experimental design, engineering design, and survey design.
- To overcome the cultural, conceptual and linguistic differences between the different disciplines, collaborative work between designers and scientists should be underpinned by effective communication. This involves frequent contact with the team members to gain a mutual understanding of key issues and to appreciate what each group considers important.

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