UX DESIGN

maximising the value of scientific software in life science R&D

Using scientific software can be frustrating and time-consuming, resulting in less productive research. This article aims to demonstrate that User Experience (UX) Design – an evidence-based design process that centres on the behaviours and needs of users – offers specific efficiency benefits for life science R&D. Already well-established in other industries, such as retail and finance, UX design holds great unlocked potential for scientific software design. Because it offers a clear path to differentiating a business and reaping benefits for the discovery pipeline, the authors suggest ways to incorporate it seamlessly into life science R&D.

By Dr Jennifer A. Cham and Katrina Costa

What actually is UX design, and how is it used by R&D organisations? We reflect on the latest business reports and our own investigation into the current UX capabilities of nine leading, blue-chip, research-based biopharmaceutical companies. We also introduce a new Pistoia Alliance initiative: 'User Experience for Life Sciences', which involves ~50 UX design experts from ~16 organisations. The goals of the project are to demonstrate the business value of UX using life science R&D case studies, and to provide practical methods to achieve success.

Smart science, but not-so-smart UX

"Leading firms invest in UX. Those that don't leave themselves at risk"[1]

Imagine hiring the best scientists to solve an extremely complex problem – such as discovering a new drug – but providing them with software that is hard to use, slow and unattractive. It would be like inviting the biggest pop stars to play a huge arena, without amplifiers. The science may be cutting edge, but without UX, it will fall flat.

The best companies want their scientists to have the most efficient, engaging means to perform their research. Yet, invariably, the experience that many R&D scientists actually encounter in their daily work is subpar – far below their omnichannel, immersive digital experiences outside of work. Companies that invest in UX for their external products may not see the need to do the same for their internal scientific software, which has an impact on the efficiency of their discovery teams.

The hidden UX capability of life science R&D

If you are curious about UX in drug discovery, you may find it hard to learn more. When pharmaceutical companies report on UX, they typically focus on external aspects, for example, the application of good UX design for customers, clinical touchpoints and marketing[2,3]. However, UX for internal processes goes unremarked.

As part of the new Pistoia Alliance collaborative project into UX for Life Sciences[4] (UXLS), we collated data on the internal UX capabilities of nine global research-based companies[5]. All nine are represented in the top 15 biopharmaceutical companies by revenue in 2016[6].

Minding the 'UX gap' in life science R&D

"If you think good design is expensive, you should look at the cost of bad design" – Dr Ralf Speth, CEO of Jaguar Land Rover[7]

A 2015 business research report[8] highlighted that big firms are keen to broadcast their commitment to UX, for example by announcing:

- Their UX spend (see an IBM report in 2014[9]).
- UX recruitment drives, such as GE, 2014[10].
- Acquisitions of UX agencies, such as Capital One which acquired Adaptive Path[11] and BBVA who acquired Spring Studio[12].

Surprisingly, many of the businesses actively investing in UX (or buying UX firms outright) are not those in creative industries, but instead include financial service companies such as Capital One and Square[13]; technology firms such as Adobe and Salesforce[14] (CRM software); and management consultancies such as Accenture[15]. Even the complex field of rocket science is embracing UX design[16]. Life-science businesses may, however, be missing out on this upward trend. Our research shows that the maturity and size of UX capability within biopharmaceutical R&D organisations is hugely varied, from no UX function at all within R&D to one company deploying 25 FTEs in teams at four sites across three continents (**Figure 1**). There are no reported examples of acquisition of UX agencies in R&D-based life science companies yet.

According to 2015 research[17], the ideal ratio of UX designers to software developers is minimum 1:12, and ideally 1:4, but this is taking a simpler picture than for biopharmaceutical R&D. A more sensible (realistic) ratio may be two or three per 100 R&D headcount, or a flexible ratio which divides UX capability by project or department. A further recommendation would be to always consider having dedicated UX support when third-party software is to be reviewed for purchase for R&D.

Eight of the nine biopharmaceutical companies we asked also use external agencies for UX services. They are hired particularly for usability evaluations, so this may be another way to improve the UX ratio at times of peak demand.

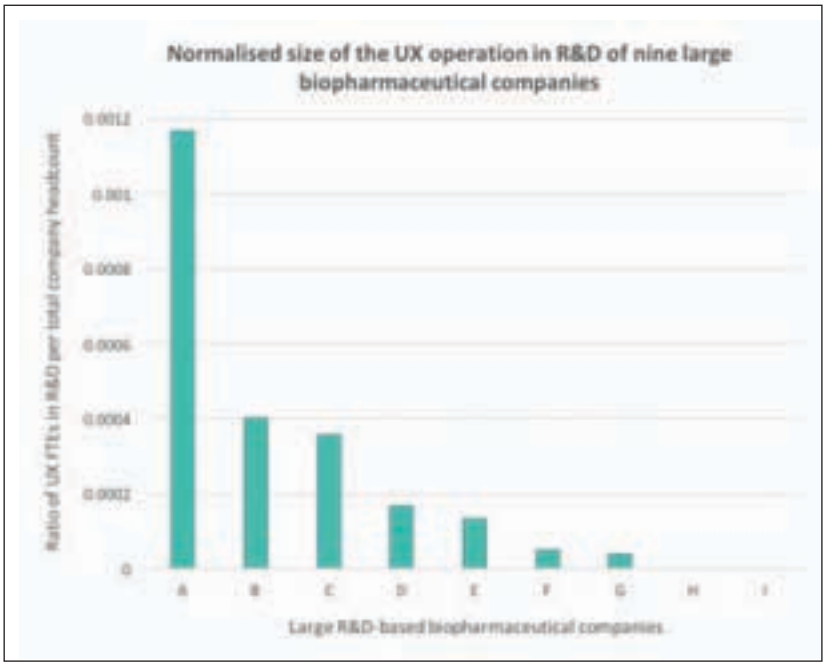

Figure 1
Summary of the current UX capability of nine large biopharmaceutical companies. Company C, for example, has a UX team of 25 people and total headcount of 70,000 (ratio = 0.000357). Company H has no dedicated UX function in R&D; UX effort is only applied to external consumer-facing products. Company I has UX embedded only in development teams that elected to switch to UX methodologies, no central mandate for UX exists

How life science R&D organisations structure UX functions internally

Even at the ideal ratio, a 'UX headcount' alone will not make life science R&D automatically realise the benefits of UX design[18]. There are three basic options for structuring UX capabilities effectively:

1. Have a dedicated design team ('design studio') internally.
2. Have designers distributed throughout the organisation, effectively embedding design deep into your operation.
3. A combination of 1 and 2.

A hybrid approach of 'design studio' and dispersed designers is best. If designers are embedded, then 'design thinking' lies at the core of one's company and good design will influence all the decisions that are made. Adding a dedicated design team will create an aspirational place for designers and, importantly, help to attract talented designers.

"Big companies can be stifling for the creative set, but ...GE's design team operates almost like a start-up inside of GE."[19] *And at NASA they have "essentially a design consultancy inside... that builds user-centred software for various teams across the agency*[12]*."*

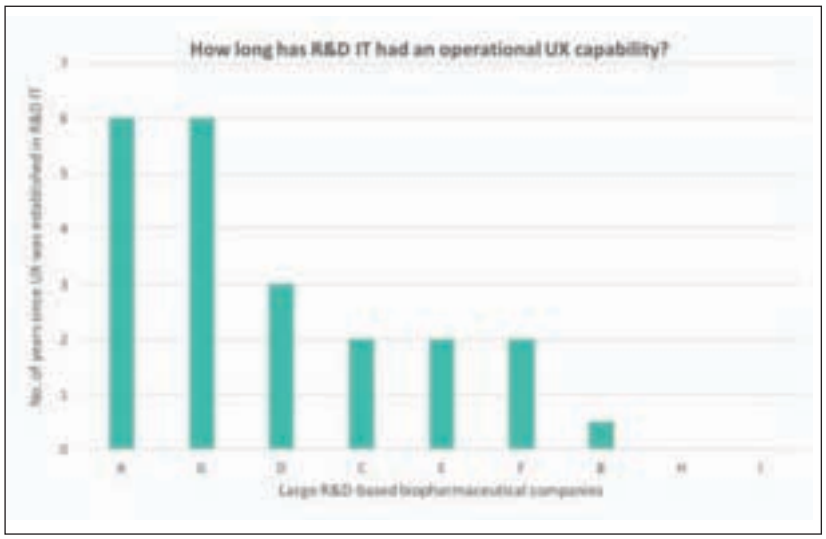

Figure 2
Number of years of operational UX in R&D IT for the nine biopharmaceutical companies we investigated. Company A also had the highest UX FTE ratio (**Figure 1**) and is tied with Company G for longest-standing UX team. Company F has a smaller ratio, but a longer-standing team

Having an attractive environment is crucial, because hiring skilled UX personnel may not be easy. According to a 2014 survey, 'UX Designer' and 'Developer' top the list of hard-to-fill roles, with more than 44% of digital-experience decision-makers saying they had difficulty recruiting them[20].

Our investigation showed some biopharmaceutical companies may be doing a better job than others at demonstrating UX value internally. This is reflected in the size of the UX teams (**Figure 1**) and the number of years companies have been investing in UX capability (**Figure 2**). We also found that within R&D IT, in-house UX design 'agencies' may be referred to as 'Centres of Excellence', 'Competency Centres', or 'User Centricity Programmes'. These titles are more suited to the culture of the pharmaceutical industry.

Seven of the nine companies we surveyed reported their UX capability directly overlaps with business analysis. Supporting comments from leadership include: *"We have 12 usability experts for 'experience exchange' throughout the organisation"*, and *"We practise democratising UX via champions in user-facing groups, and actively support projects with any UX involvement"*.

One company described having a specific role for *"strategic integration of UX into R&D"*.

Composition of UX teams in R&D IT

Seven of the nine companies we asked have a centralised UX team in R&D IT. **Figure 3** illustrates the specific roles in these teams.

Scientists turned UX Designers, or UX Designers turned scientists?

Few UX professionals have a scientific background (**Figure 3**). They are far more likely to have a background in psychology, human-computer interaction (HCI), technology, cognitive science, human factors (engineering) or design education. University programmes (eg UX, HCI) and professional membership bodies (eg the Usability Professionals Association[21]) now bolster the profession.

A lack of scientific training allows UX designers to ask questions without restricted thought patterns (sometimes called 'the curse of knowledge'). Designers do need enthusiasm for science, and

Figure 3
Composition of UX teams in R&D IT, based on information from the nine sample companies. In German-speaking countries, a 'UX Designer' is usually referred to as a 'UX Engineer'. Asterisk means the team includes a science domain expert UX designer

Job Title	Description of the role	A	B	C	D	E	F	G	H	I
UX Designers	*Design all user-facing aspects of a system. Improve the usability, productivity and pleasure provided in the interaction between a user and a software application.*	✔*	✔	✔	✔	✔	✔	✔	*no UX team*	*no UX in R&D*
UX Researchers	*Apply investigative methods to add context and insight to the design process with the goal of uncovering the perspective of the end user. They gather data, and synthesise it.*	✔	✔	✔		✔				
Interaction Designers	*Design the specific interactions between users and a screen (see http://ixda.org/)*			✔		✔				
Visual Designers	*Focus on the aesthetics of a site and its related materials by creating images, colors, fonts, and other elements. Overlaps with graphic design (see https://www.usability.gov/what-and-why/visual-design.html)*			✔		✔				
Copywriters	*Write text (copy) usually combining creative writing with approaches to boost Search Engine Optimisation (SEO). The aim is to encourage engagement & assist marketing.*			✔						

require the ability to tweak standard UX design approaches to accommodate biological data complexity. An example is 'canvas sort' (a variant of standard card sorting), applied to complex enzyme data at EMBL-EBI[22].

Rare scientists-turned-UX specialists make ideal candidates. Their background knowledge and intuitive grasp of practical R&D challenges offer distinct advantages when designing usability testing scenarios and tasks. This is particularly true if they are familiar with the types of data being used, as they can create realistic usability tests, for example. For researchers seeking a career change without leaving science, it is well worth exploring UX Design as a profession[23].

Life science research is constantly changing and new technologies (eg CRISPR, RNASeq, next generation sequencing) are increasingly available. All UX specialists, regardless of their background, need to keep up-to-date through continued professional training in the life science field.

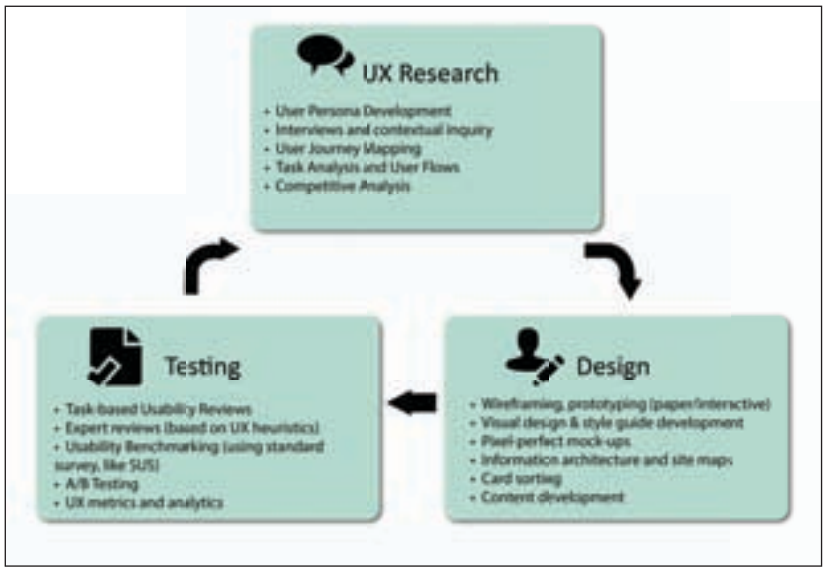

Figure 4
UX design employed throughout the product development process. It involves techniques for user-centred design, evaluation and overall alignment with the organisation's business goals. A UX specialist will be able to do everything, from identifying pivotal problems through to mapping user journeys, designing websites and validating the approach. The figure shows methods that were explicitly described in our survey of nine companies

Scope of UX work in life science R&D

UX design for life science R&D serves internal research scientist users first, with the main goal of facilitating data analysis and visualisation. However, the nine companies we reviewed reported that UX teams can also be tasked with delivering projects for enterprise-wide internal processes (eg compound registration systems, reporting, collaboration, supply chain, manufacturing, business intelligence) and external products. One company said: "[We work on] a variety of colleague-facing, scientist-facing, healthcare professional (HCP)-facing and patient-facing digital tools. Anything from our corporate intranet site to connected self-medication devices."

UX is also important for Business-to-Business (B2B) scientific software. Criticisms levelled at purchased IT systems often centre on poor engagement, adoption and acceptance by internal users (ie scientists). UX-designed software solutions, how-

Figure 5
Good UX empowers scientists. Example case study from Novartis: "We created an app to support lab-based researchers by combining and harmonising their workflow(s), reducing human error rate and closing all gaps. We achieved this through interviews, user testing and other research methods. The UX team created a custom-designed solution, including software for mobile and grounded devices, to meet our researchers' complex needs, while feeling intuitive and easy to navigate." *Image copyright: Novartis*

Figure 6
Storyboarding is one example of a UX technique employed to understand R&D user needs. *Image copyright: Novartis*

ever, focus on the tasks and context of scientific work. This emphasis vastly improves uptake, and accordingly return on investment, over traditional 'systems-analysis' and off-the-shelf procurement approaches, which follow a more linear process of gathering requirements and carrying out acceptance testing.

Six of the 16 member companies in the Pistoia Alliance UXLS project team are research technology vendors. They showcase the potential of UX design to support scientific software suppliers, with one company, for example, making "usability an integral part of our development and software selection processes".

What do UX designers do?

Effective UX design stems from the judicious engagement of skilled UX practitioners, melding their work with the rest of the R&D operation. It requires thorough insights into the behaviours and needs of its target users. The 'central dogma' of UX design is cyclical iterations of discovery, design and testing (**Figure 4**). UX design is an approach to be embraced by everyone in product/service design teams – not just a series of tasks to be carried out by team of 'UX wizards'. Experts from different fields must share an approach to solving design problems that prioritises the users' needs. This results in greater buy in, which leads to higher satisfaction with the end result (example in **Figure 5**).

Like science, UX is a way of thinking

UX researchers and designers must fully understand the challenges faced by scientists. For example, they need to insight into: the barriers to exploring new scientific ideas; problems in the physical environment where a device is used; stop-and-start disruption due to lack of integration in tools; data and workflows; and myriad issues with sharing their work with others.

UX research helps inform the right design decisions early, enabling software coders to create useful products and features, and avoiding costly reworking. During the design phase (see **Figure 4**, 'design' and a real example in **Figure 6**), the new product is envisioned and measures of success are planned (more on metrics later). By using hypothesis statements, requirements can be turned into tests for determining if the product has been successful[24]. For example:

"We believe this [business outcome] will be achieved if [these users] successfully [attain this user outcome] with [this feature]."

Specific UX techniques are then employed to evaluate and test (see **Figure 4**, 'testing') what has been designed with real users, as early as possible. This increases engagement rates and uptake of new tools because the product hasn't been shoe-horned into an existing process. Instead, it dovetails with good design decisions along the way.

Challenges for venturing further into UX for life science R&D

It is possible for the drug discovery operation to become truly UX design-capable, but there are a few specific hurdles in this environment.

Poor awareness of the role of UX design in life science R&D

When UX design is new to an organisation, there can be misconceptions about what it is, and how it benefits the business. If senior decision-makers in the organisation do not value it, it will not garner the attention it needs[25].

UX design may be perceived as an 'idea-generating exercise', rather than a problem-solving approach. Staff may mistakenly assume that 'UX' and 'user interface' (UI) are the same thing. UX may be seen as something done at the end of software development, rather than a life-cycle process. The UX team may only be asked for comment post-interface design, coming back with a short critical report, stifling any future collaboration. In reality, "UX is about the arrow hitting its target, it is not about how beautiful the arrow looks."[26] This message needs to be communicated and internalised.

Stakeholder buy-in for UX in life science R&D

Managers must realise that the design of products and services for internal R&D scientists is business critical. Good design must be incorporated into everyday processes of R&D, alongside project management, business analysis and operations management. Evidence gained in UX research should influence decision-making and override existing norms – this can be a challenge for entrenched leadership.

Managers should undertake a 'UX capabilities assessment'[27] to independently gauge their organisation's UX maturity. Questions to ask include: is UX considered in horizon planning? Is there budget for UX when a new solution is being developed, an existing one is being redesigned or a new IT solution procured?

Creating the right organisational culture for UX in life science R&D

Life-science R&D IT is generally regarded as a cost centre rather than an important opportunity to add business value and to differentiate. This mindset may also explain why UX has been overlooked in life science R&D. It is rare for designers to rise up the echelons of senior management. For UX to have influence, leaders must have already

Figure 7
Strengths of the UX team

witnessed the value-added by good design; in other words they must be 'design-evangelised'.

UX must influence strategy in life science R&D

Unlike business strategists, who are good at spotting business opportunities, influencing senior decision makers and building a business case, UX designers tend to focus on people-centred issues such as empathy and engagement. These have substantial impact, but are more difficult to demonstrate and quantify (**Figure 7**). As a result, UX directly may not be a great tool for influencing senior decision-makers. UX is perhaps more 'heart', compared to other business functions that are more 'head'.[28]

UX education for the enterprise

So how can you raise awareness of UX within a life science R&D company? We have encountered specific initiatives in our investigation that make a difference:

- In-house UX toolkits empower non-experts to carry out UX work themselves, so they see the benefits in their own projects. Seven of the nine companies we researched also offer an internal UX coaching 'kit' for their colleagues, including a 'UX Playbook', usability guides, tools, templates, guidelines, examples and style guides.
- One of the nine companies mentioned using case studies of success stories of applying UX internally (and externally).
- Dedicated UX training programmes for R&D IT staff are in place in some of the companies, with one having dedicated online training modules. (NB: UX design on MBA courses would be helpful, but we have not observed this.)

Return on UX investment

Economist Edwards Deming famously said: "If you can't measure it, you can't manage it." However, he also said: "There are many things that cannot be measured and still must be managed... Much more than managing what you can measure is needed to manage organisations well."[29] UX teams are very familiar with this paradox.

Another recent article states more specifically: "Executives want to know the ROI for the products and solutions their company creates [or buys]. They typically want to know the ROI for UX efforts, too. However […] a product's UX is so pervasive that trying to determine isolated UX metrics is futile."[30]

It can be tricky to identify the exact underlying

Figure 8
Participants at the inaugural workshop in September 2016 organised jointly by EMBL-EBI and Pistoia Alliance. This two-day meeting provided an opportunity for the existing Pistoia Alliance UX community of interest and other interested individuals to meet face-to-face for the first time and to start working on ideas to address common challenges faced by UX practitioners in life science R&D environments

problem UX is trying to solve, and doubly challenging to measure if the UX has been successful.[31]

What are life science companies currently doing to measure UX impact?

We asked the nine companies how they quantify the success of UX in their R&D business. Many of them use specific tools to assess user satisfaction, including:

- A system usability scale (SUS)[32]: a 'quick and dirty', yet reliable tool for measuring usability. It comprises a 10-item questionnaire with five response options.
- Net Promoter Score (NPS)[33].
- 'Voice of the User' surveys.
- How well products and services compare with customer expectations, eg via customer satisfaction (CSat)[34] methodology, task completion rates, or having another project specific metric/KPI.
- A 'joyfulness' six-question survey, which polls every six months.

Qualitative methods may also be used to measure the quality of the user experience. A specific approach is the HEART framework[35], which provides a comprehensive, project-specific approach to measuring UX success, balancing user satisfaction with adoption, engagement and task success.

The companies also mentioned less tangible UX yardsticks, including measuring the internal demand trend, tracking expansion of UX services over time and carrying out direct user-feedback sessions. Only one company said it did not measure UX performance *per se*, rather overall system success.

These measures help make the business case for UX. Our data sample shows (**Figure 2**) that in the past few years, life science R&D companies have invested more into their UX capability. However, the ratio of UX headcount to total staff (**Figure 1**) is probably still too small to make a real impact. If more meaningful metrics for managers were available, wider adoption and investment in UX would be more likely. We did not see a specific role for an analytics/metrics specialist in the UX teams we investigated (**Figure 3**). It may be an assumed skill of the UX designer, or it may be a missed opportunity.

User experience for life sciences: Pistoia Alliance fills the gap

The Pistoia Alliance (PA) is a global, not-for-profit consortium of life science companies, technology product and service providers, publishers and academic groups that work together to lower barriers to innovation in life science R&D. PA projects transform R&D innovation through pre-competitive collaboration to identify root causes of R&D inefficiencies.

In January 2017, PA launched a project involving 50 UX design experts from 16 member organisations including pharmaceutical, agri-food, life science and technology companies. The User

Experience for Life Sciences (UXLS) initiative aims to communicate the value of UX in life science R&D. Using shared knowledge and best practice, the project partners are also developing a UX toolkit with R&D-specific case studies, methods and business metrics.

Nurturing the UX network in the life sciences

A workshop (**Figure 8**) helped forge this new community by exploring and articulating the shared challenges of UX practice in life science R&D.

"It's exciting to get to know so many UX professionals and practitioners from many different pharma companies and vendors," says Pat Keller, Global Head of User Experience at Novartis, NIBR Informatics. "Face-to-face meetings mean we can work together to create a better place for UX in life science. Everybody is passionate, everybody wants to improve the industry, and that's what gives this group momentum, inspiration and motivation to achieve its goals."

Through this new professional peer network, there is an opportunity to establish thought leadership in the area of UX in life science R&D and to influence senior decision makers. A follow-up workshop at EMBL-EBI in June 2017 will include R&D IT senior vice-presidents and directors from leading pharmaceutical R&D companies.

Providing a UX toolkit for life science R&D

Each project team member, co-ordinated by a PA project manager, is working on a *pro bono* basis to deliver the free online UX toolkit, positioned to help improve the quality and usability of scientific software. By sharing their deep knowledge of UX, gained in the field of life science R&D, they will help others foster UX best practices in their own companies.

The new toolkit will benefit organisations with a UX team of one, and those with much larger UX departments. In the project's next phase, partners will develop UX metrics to help users measure and communicate the impact of their work. There are two main benefits of this toolkit:

1. It supports cultural change in research organisations where UX design is undervalued.
2. It provides practical support, helping UX (non-science domain expert) professionals understand how research scientists work, so they can help create better digital experiences.

The toolkit is targeted at UX practitioners, business analysts, software developers and managers of technical delivery teams. The first full release is scheduled for Q4 2017. To register your interest see: http://www.pistoiaalliance.org/projects/uxls/.

The Pistoia Alliance: new UX opportunities in R&D

There are clear opportunities for pre-competitive UX projects in life science R&D, for example improving the UX of clinical trials, where many companies suffer the effects of poor patient engagement. UX mapping from both the patient and caregiver perspectives could help to reduce attrition rates and improve patient compliance. UX research and design could also greatly improve product development in a range of R&D settings, including patient consent solutions and 'laboratories of the future'.[36]

Further Reading

Free online UX training module provided by EMBL-EBI https://www.ebi.ac.uk/training/online/course/user-experience-design.

Open Targets[37] (http://www.targetvalidation.org/) is a good illustration of a software solution designed for life science R&D using a user-centric approach[38]. It allows bench biologists and disease experts to execute complex queries on target and disease information in an intuitive way, without the need of expert computational biologists, thus saving costs and increasing efficiency. DDW

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37 A web application for target validation created through funding from GSK, Biogen, EMBL-EBI and Sanger Institute. http://targetvalidation.org.

38 Koscielny, Gautier et al. Open Targets: a platform for therapeutic target identification and validation. Nucleic Acids Res (2017) 45 (D1): D985-D994. DOI: https://doi.org/10.1093/nar/gkw1055.