

Institution: Bournemouth University

Unit of Assessment: 11 – Computer Science and Informatics

1. Unit context and structure, research and impact strategy

1.1 Unit context and structure

Computer Science and Informatics research at Bournemouth University (BU) is driven by 46 academic staff including 8 professors and associate professors. Our research is structured across six topics or 'research clusters' underpinning our current success and future research and impact strategies:

- Cyber Security
- AI and Data Science
- Human Computer Interaction
- Social Informatics and Software Engineering
- Computer Networking
- Games Technology

The emergence of these groupings was guided by the overall aim to grow the Unit and by the sustained effort to build critical mass around areas of research strength as part of the Unit's strategy. The goal of stimulating the grouping is to enhance the productivity as well as the internal and external visibility. In addition, a number of interdisciplinary areas have emerged over the years such as: medical robotics, telecare/telehealth, behavioural change, aging and dementia, visualisation and graphics, game development, and big data, which have all enabled UoA11's researchers to collaborate with others in various faculties and research groups across the university.

Computer science and informatics research is conducted mainly by two departments: Department of Computing and Informatics (CI) and the Department of Creative Technology (CT). Whilst most of the staff in these departments are returned in UoA11, the interdisciplinary nature of our research has led to some departmental research being submitted to other units such as UoA32 (Art and Design: History, Practice and Theory). One staff member from the Design Department contributes to UoA11 as his work is related to assistive technologies using AI, illustrating the cross-cutting interdisciplinary nature of the research undertaken across three departments.

The breakdown of our submission by cluster is as follows:

Cyber Security	16%
AI and Data Science	33%
Human Computer Interaction	18%
Social Informatics and Software Engineering	10%
Computer Networking	13%
Games Technology	9%

In 2014, UoA11 was not returned to REF. Instead, the few Computer Science staff from both CT and CI were returned in UoA15 (General Engineering). Among the objectives in this REF period (please see below), the main one, as a first step towards laying the foundation of a strong and vibrant Unit, was to focus more on changing the research culture and improving the research environment given the young age and history of the Unit at BU. The Unit has achieved this objective.

During 2014-2021 this Unit facilitated substantial growth of research in related subject areas, supported diversification of research activities, catalysed exchange among individual specialisms and radiated the impact to a wide spectrum of industry. Key achievements include:

Research active staff – We supported more than a three-fold increase in the number of staff actively undertaking independent research to 45.75 FTE (see section 2).

Research income: We diversified research income sources (see section 3) with total research funding income increasing by 289% from £1.1M in REF2014 (Computer Science proportion) to £4.3M in REF2021, with substantial increases in particular to contract research (689%), open competitive research (179.04%), KTPs (115.18%), and match funding studentship by industry (50%). The average annual income has increased by 61% from £382K in REF2014 to £615K in this period.

Societal Impact: We collaborated with a large number of industrial partners (circa. 500) which led to over 120 successful collaborative research projects to facilitate knowledge exchange and generate direct impact to the related industrial sectors.

Research output: We supported staff to publish research with the number of research publications increased by a ratio of 69%, encompassing different venues (top journals, conferences, books and book chapters) (see section 4).

Research students: We have increased PhD registrations by 20% with completions rising by 247% from 14.71 in REF2014 to 51 in REF2021.

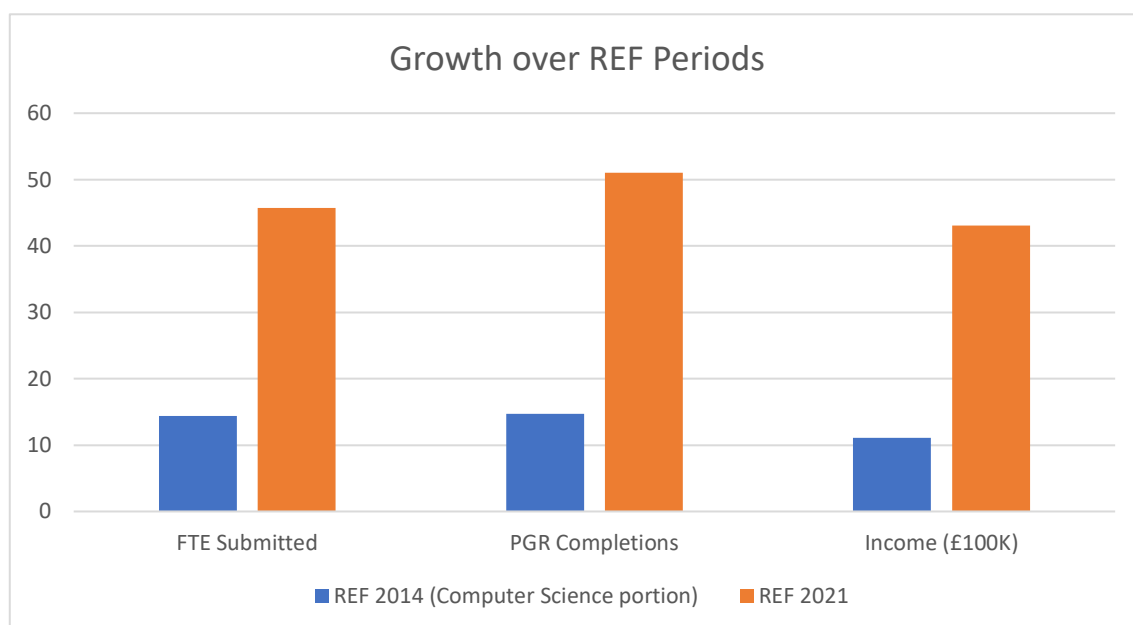


Figure 1. Comparison between REF2014 and REF2021 submission

This submission outlines the Unit's research and impact strategy, highlights the achievement towards establishing Computer Science as a REF-returnable discipline at BU and consolidates the excellence of work the team have done over the current REF period.

1.2 Research and Impact Strategy

Our purpose at BU is to inspire learning, advance knowledge and enrich society. We stress the importance of societally relevant research alongside continuing excellence - our research influences our curriculum and is passed on to industry through engagement with practice. In this context our Unit's strategy is to continue with established approaches but with a more explicit focus on innovation and engaging productively with societal challenges.

The Unit's research and impact strategy has been developed alongside the institutional strategies of BU2018 and BU2025 (See REF5a). We have made strategic investment to broaden our research specialisms in order to address societal challenges and to inspire staff/PGRs to embrace innovation. The strategy spans the following key dimensions:

- Establishing a vibrant and sustainable research environment

- Ensuring development and support for researchers
- Developing an effective and productive research structure
- Increasing and diversifying the research income
- Enhancing the quality of research output
- Increasing registration and completion of PhDs

In line with these dimensions, a number of strategic objectives and associated key performance indicators (KPIs) are monitored regularly with the aim of improving performance. Our strategic objectives will continue to 2025 to ensure sustainability whilst enabling critical reflection about them if needed.

Building on our research strengths, we have used the following integrated research and impact objectives (**O1-4**) to transform our research environment over the REF period:

O1 - Scientific excellence and sustainable growth:

Computer science at BU is driven by the aim of producing high quality research in line with the Fusion principles adopted in 2011 and the university strategic plans BU2018 and BU2025 (see REF5a). In addition to education and professional practice, all staff members have to enhance their research output and grow their internationally excellent and world-leading research. To enable that, the CI and CT departments went through restructuring leading to more organised research themes and teams and to the creation of a new “Deputy Head of Department” role, to specifically support the research activity within the departments. A number of appointments have been made including: 11 lecturers, 3 senior lecturers, 1 associate professor, 2 principal academics and 2 professors. Moreover, a number of promotions to professor have been made (4). In this REF period the Unit’s staff published: 357 journal papers, 24 books and proceedings, 70 chapters in books, 772 conference and workshop papers, 7 patents; an increase of 69% compared to the REF2014 period indicating a good breadth of research base.

As a result of this strategic objective and various support mechanisms we have supported a more than three-fold increase in the number of staff actively undertaking independent research to 45.75 FTE.

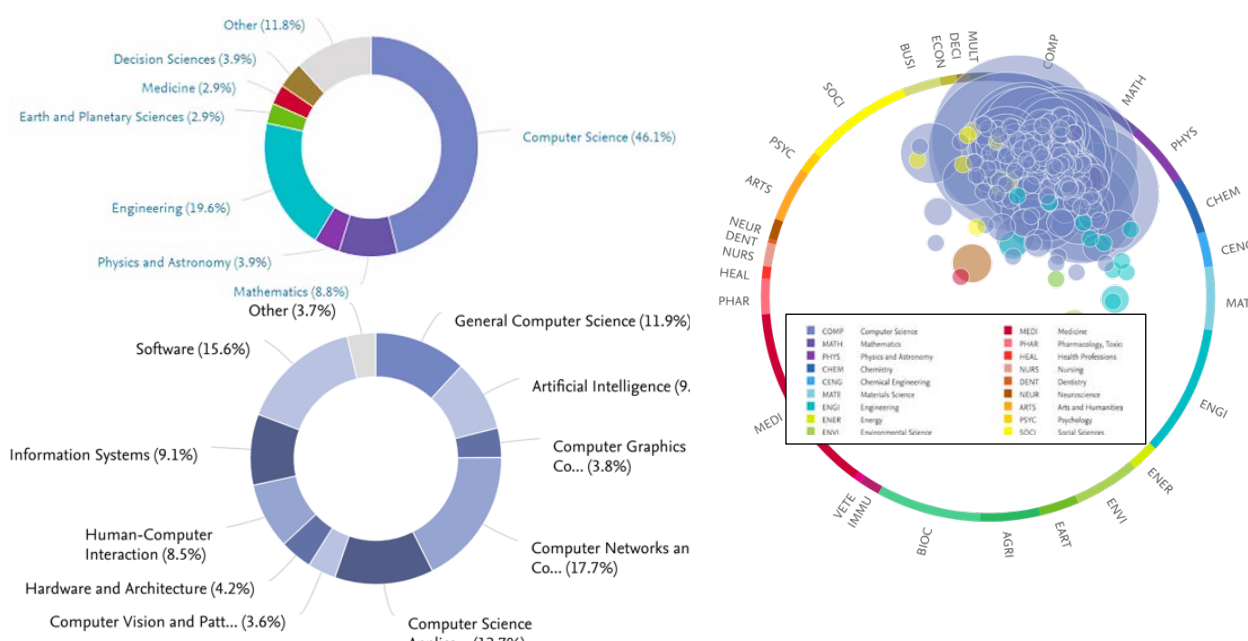
O2 - Stimulate interdisciplinary research towards key societal challenges:

Given the versatility of computer science research, the Unit has always encouraged interdisciplinary research to tackle real-world problems. The Unit strategy consists of: **i)** disseminating our research internally at BU and externally in formal and informal forums before researchers in other disciplines, **ii)** engaging in applied research (that is usually relevant for interdisciplinary work), **iii)** sharing information about interdisciplinary funding calls and governmental strategies in various sectors among different cohorts of staff, **iv)** foster collaboration between interdisciplinary researchers around BU strategic investment areas. Strategically, BU provides various training opportunities covering inter-and multidisciplinary research by inviting experts and organising workshops for this purpose. The Unit advertises such meetings, targeting very specific staff members (those who are less active and ECR members) to take advantage of cross-discipline networking. The Unit has capitalised on these initiatives and as a result of this effort, a number of interdisciplinary areas have emerged over the recent years such as: medical robotics, telecare/telehealth, behavioural change, aging and dementia, visualisation and graphics, game development, and big data, which have all enabled UoA11’s researchers to collaborate with others in various faculties and research groups across the university. As a result of this the Unit has witnessed a noticeable progress in terms of interdisciplinary and multidisciplinary collaboration.

Key interdisciplinary initiatives driven to tackle key societal challenges are:

- a. Medical robotics (Dubey, Vaughan and 2 other staff) merging virtual reality and robotics to develop two simulators: a virtual engineering-based hip model (winning the IET Innovation Award 2016) and Patient-specific Epidural Simulator for Training.

- A number of interdisciplinary and multidisciplinary publications have resulted from cross-domain partnership and collaboration as shown in the figure below:



These figures illustrate the split of topics covered by UoA11, particularly the interdisciplinary and multidisciplinary nature of its research.

One of BU's UoA11's strategy has been to foster a strong development of impact in its own right, as this is the first time that BU is submitting a UoA11 to the REF exercise. In order to embed the culture of impact within the Unit, which is integral to UoA11 at BU, we endeavour to make sure that the Unit research is framed by the needs of industry, ultimately being applied for the benefit of the economy and society. This strategy has been shaped by BU2018 and BU2025 strategic plans, which focus on societally relevant research and the Fusion of research, education and practice. Where research has the potential for commercial development, researchers are encouraged to: **i)** develop follow-up of R&D projects, **ii)** prospect match-funding of PhD students to see impact within the remit of the sponsors' activities (especially companies) and **iii)** call on the help of companies to commercialise the results generated by UoA11 research where relevant. Beyond this, pathways to impact mechanisms include: consultancy, public engagement activities (e.g. Festival of Learning, invited talks, Research Blog, Café Scientifique, Pint of Science), as well as developing thematic areas for applied research around Cybersecurity, Engineering of Social Informatics, Data Science and e-Health.

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impact case funding. These streams have supported the submitted impact and other emerging cases as well as PhD projects (Dogan's on HCI for Smart WheelChair), the Digital Addiction initiative which has a rich outreach program (Ali et al.) and the ethical penetration testing (Faily).

One of the main types of impact has been the change in process and technology, through the adoption of research results in the form of direct software provision or licensing (e.g., Energy Technology Institute (ETI), Bouchachia; ArcelorMittal, Bouchachia), or through take-up of our published research results to generate new technology. Over the reporting period, our research has been characterised by a combination of high-quality research impacting onto various types of beneficiaries: vendors of technology, non-profit organisations and well-being agenda, user communities, as well as policy makers. The research conducted by the Unit researchers is highly inter-disciplinary involving: computing (wide range of sub-disciplines), psychology, law, norms and ethics, medical and social care, business and marketing, as well as entertainment and well-being. The range and scope of the impact cases presented within UoA11 demonstrate a varied range of impact across economic impact and wealth creation, health and social care impact, policy change, as well as societal impact and well-being agenda.

As indicated in *Section 1.1* above, our current and future research strategy is focused on delivering impact. As a community of computer scientists, this is fundamental to the philosophy of our work. We are developing tools for various organisations such as: Dorset Clinical Commissioning Group, ArcelorMittal, ETI, etc. to build on our guiding belief and respond to the needs of industry and society to maximise the impact of our research.

We have established courses delivered by the university's Staff Development Programme, e.g. social media for research, networking and engagement, developing business cases, training on developing pathways to impact (Grant academy, KTP awareness, Briefing by Experts, Research Development & Support department (RDS)'s initiative on impact and evidence collection). We have invited industry and charities to be part of the research as collaborators and also as exploiters, e.g. Streetscene, Poole DAAT, YADAS, NHS, Bournemouth Hospital, Bournemouth-Christchurch-Poole council, BEIS (Government Department for Business, Energy and Industrial Strategy), and a wide range of SMEs in the Dorset area (e.g., JP Morgan, BAE Systems, Wessex Internet).

We have also been working closely with RDS and marketing to efficiently and creatively disseminate our research outcome and access different users' and exploiters' groups, especially considering that a good segment of our research relates to public interest (e.g., e-Health, Digital Addiction, and Engineering of Social Informatics). We also distribute in different languages (which is rarely the case of other universities) and in different formats, not only written articles, e.g. Animation, Cartoons, Videos (Faily's *Undergraduate Research Assistantship* is a good example).

We ensure that our state-of-the-art facilities, which are developed / customized / extended based on our research, is available to external users for testing and feasibility studies, e.g. Police, NHS, etc.

We also provide an approach which facilitates an open source and publicly available research outcome is easily accessible for both research and industrial purposes. We are developing apps and social platforms within this remit, e.g. the Crowdsourcing Configuration, the Digital Addiction Stats and Dashboard, etc. Our recognition as contributors to the knowledge transfer, e.g. in the dataset we offer, should be planned carefully.

The Faculty is supporting staff to plan for impact early on and provide help in finding industrial and societal connections through the public engagement program of the Research Centres. We also providing support to existing and pump-prime research by our successful EU projects, the successful mobility and networking initiatives and the seed fund, mainly Fusion, which helped colleagues to establish their niche areas.

Finally, effective mechanisms for the measurement of impact and the collection of evidence for all research groups and centres include the UoA11 REF review committee and an online system to allow recording and categorising of impact.

Our current four case studies illustrate the above approach and strategy, each one representing a different aspect as well as being representative of our main application areas:

- Impact Case Study 1: Design Techniques and Tools for Security & Privacy by Design, has made an impact on the design, development, and operation of security and privacy preserving software.
- Impact Case Study 2: Transparency and Data for Empowering the Responsible Nature of Online Gambling, which should be provided in an automated, real-time manner to gamblers and their surrogate parties, human or software, to help the predictive and proactive prevention of harmful gambling.
- Impact Case Study 3: Combatting Digital Addiction which tackled the problem from a unique perspective: studying the potential use of digital addiction labels, using software not only to monitor how people use technology but also to react to it with advice and statistics.
- Impact Case Study 4: Establishing Models of Internet of Things (IoT)-related Crowdsourced Systems, has established an ITU-T work item (specialised agency of the United Nations responsible for issues that concern information and communication technologies) within Study Group 20 IoT and smart cities and communities / Question 5 Research and emerging technologies, terminology and definitions.

O4 – Promoting technological innovation and industry collaboration:

The Unit endeavours to be a catalyst for impact by advancing knowledge, creativity and innovation, by driving social and economic growth and development in the region, and to leading thinking on sustainability. UoA11 has established strong relations with:

- Businesses (*ArcelorMittal*, *Unilever*, Bouchachia, *SETsquared Partnership*, Faily; *Naim Audio Ltd*, Cobb; *OML*, Cobb; *Streetscene Addiction Recovery*, Ali; *County Coaches LLP*, Sahandi, Prakoowit; *British Telecommunications Plc*, Mecham; *Starlight Culture Investment Pte Ltd*, Tian; *Beijing Kehai Sports Co Ltd*, Tian; *Creg Handaz Nigeria Ltd*, Sahandi; *Dongying Oil Technology Development co., Ltd*, Jiang; *Ninja Theory*, Gatzidis; *Sony interactive*, Gatzidis; *My mHealth*, Gatzidis; *Guide Dogs for the Blind*, Prakoowit; *County Coaches*, Prakoowit; *Smart Sure*, Davis; *Caspia*, Davis; *Bengaged*, Davis; *Curamicus*, Davis; *XIM*, Bouchachia).
- Public organisations (*DSTL*, Faily; *NHS*, Bouchachia, Dubey, Yu; *Energy Technology Institute*, Bouchachia; *New Forest National Park Authority*, Davis; *Dudsbury Guide Camp*, Davis).
- Public administrations (*Bournemouth Council*, Bouchachia, Katos, Chai, Angelopoulos; *Dorset Local Enterprise Partnership*, Bouchachia), Dorset clinical commissioning group (Bouchachia).

These relationships have been triggered as part of KTP; (Computational Mechanics International, Apeh; Precision Acoustics Limited, Stefanidis; My mHealth, Gatzidis; We Are Base Limited, Budka; Bluestar Software Limited, Budka; Chantacre Limited, Main; Time and Data Systems International Limited, Yu), EU projects (PROTEUS, Bouchachia; Gamewise, Gatzidis; GameBiz, Gatzidis; FUSION, Yu; cLINK, Yu; RABOT, Yu; SOCIAD, Ali; AniAge, Yu; SMOOTH, Yu; ENISA PO 2, Katos; Incident Development, Katos; EduWeb, Katos; FIRST, De Vrieze), charities (Gambling Trust/GambleAware, Ali), consultancy (BU Cybersecurity unit, Energy Technology Institute), fully-funded studentships (EPSRC - CDE doctoral training centre) match-funded studentships (from at least 21 organisations). As part of research outcome, many concrete outputs have emerged such as [SOLMA](#) (machine learning), Bouchachia; Algorithms for human behaviour, from utility data to be exploited by the [Energy Technology Institute](#); the [EROGamb research platform](#) for responsible online gambling, Ali; BU-CERT (cert.bournemouth.ac.uk) (threat intelligence), computing cybersecurity staff, psychology staff and IT services.

1.3 Creating an Open Research Environment

UoA11 is committed to open research. A bold strategy has been in place as part of the BU's overall strategy covering: i) open research data, ii) open research activities and iii) open access. We have 98.6% compliance with the REF Open Access Publication Policy compared to 18% of journal articles being made open access in 2014.

Alongside green open access, researchers in the Unit can apply to the institutional Open Access Publication Fund to support gold open access publication. Access to such a fund is driven by the quality of the output thereby encouraging excellence. Currently a good portion of the fund (4.5%) goes to Computer Science publications.

The critical importance of an Open Research Environment to our UoA was formally recognised in 2018 with the creation of the role of a Faculty Open Data Champion to promote and facilitate these principles. The Unit is encouraging all staff as well as research students to adopt the culture of open research by using various platforms such as Github. BU researchers are asked to make the data collected during the projects (and which supports an output), available as soon as possible and for longer periods, helping to negotiate the problem before starting projects. BU now has an institutional data repository, BORDaR which currently contains various open access datasets.

1.4 Research Integrity

The Unit commits to follow the university's policy in terms of promoting and upholding the highest quality academic and ethical standards. All research undertaken by the Unit's staff and students is subject to appropriate ethical reflection, leading, if necessary, to formal approval via the online ethics checklist (the Unit applies this even to Bachelor projects). The Unit has access to the University Research Ethics Committee (UREC) which is responsible for ethical practices in relation to research and research-related activities and for establishing, promoting, implementing and monitoring the Research Ethics Code of Practice. The Unit has a representative staff member in the central Research Ethics Panel (REPs) to review and approve research ethics applications from postgraduate researchers (high risk) and staff to ensure best ethical practice is adhered to in all research activities.

Because the Unit's research covers areas like Cyber Security, AI and Data Science, Human Computer Interaction, Social Informatics that require ethical approval (such as clinical applications) and concern various confidential and personal data, staff receive training in ethics (every two years for each individual) part of the regular and mandatory training that all staff have to take. Even undergraduate students aligned with UoA11 (in Computing and Creative Technology) have to submit an ethics form before starting their final year projects. All research requiring ethical approval must be submitted to the REPs. UoA11 submits to Science, Technology and Health REP, which meets monthly. All researchers are responsible, scientifically and ethically, for the research they conduct. They are bound by obligation to comply with accountable practices within the Research Ethics Code of Practice. The researchers have the duty to inform line management and the Academic Legal Services at BU if any doubt exists so that advice and appropriate measures are taken in line with the legal and ethical requirements in place for engaging with external partners (especially in consultancy work where contracts are negotiated (e.g., Bouchachia and Budka for Respiratory Digital Innovation Hub; Bouchachia for the Energy Technology Institute)). To enhance such understanding for staff, BU organises regularly workshops on academic conduct and all Unit staff members and PhD researchers are explicitly informed by the Unit leader.

2. People

2.1 Staffing strategy and staff development

We have achieved a vibrant and sustainable research environment through a staffing strategy that recognises and values collaborative working and the effective sharing of knowledge and experience. The Unit adheres to the approach of the university and its staffing strategy, building on the Concordat set to support the Career Development of Researchers. The evolution of the Unit in terms of staffing follows that of the university which was successful in 2019 in retaining the [HR Excellence in Research Award](#), illustrating BU's commitment to aligning process and practice to the UK [Concordat to Support the Career Development of Researchers](#). The staffing strategy for this Unit supports four principal aims:

- 1) Research Excellence: Ensure that research excellence or potential are key criteria in staff appointments and promotion.
- 2) Inclusive research community: Fully support all staff in defining and developing research appropriate to career stage and expertise via mentoring and structured staff development.
- 3) Expanding PGR supervisory capacity: Support projected PGR growth and enhance PGR experience – by including structured on-going supervisory development via the Doctoral College and increasing the number of staff involved in active supervision in the Unit.
- 4) Embedding research strategy: Encourage and support staff to develop skills required to enhance impact generation and knowledge exchange, engagement and networking capabilities and further develop academic excellence, in order to expand future strategic priorities across the Unit.

As UoA11 was not submitted in the previous REF, our primary goal was to secure a submission for this REF2021. In addition to what has been said earlier, we carried forward two specific actions:

- i) Recruitment of new staff with strong research track records to support the development of the research landscape and to support the existing staff by changing the existing research culture.
- ii) Career development support to increase the capability and confidence of staff through various ways: (1) awareness, (2) provision of dedicated training (writing workshops, professional development), (3) provision of incentives schemes, from financial support through QR income and other university funds to the management of teaching load. Under the BU Workload Planning Framework all academic staff are allocated a minimum of 400 hours a year for research activities. Moreover, staff can take advantage of academic leave for up to two years to spend in industry or an academic institution. In UoA11, 5 staff members (Ncube, Askoxylakis, Fay, Ali and Rostami) have benefited from leave away in academia and industry.

The strategy of the Unit is to support ECRs to achieve senior status and senior staff to continue to build their careers. To achieve this a number of mechanisms have been put in place:

- 1- Research-informed recruitment:** To appoint academics with an aptitude for research, and ideally a track record of, or potential for, research excellence. Our strategy has been targeted at appointing academics undertaking research which builds upon our current research strengths (e.g., data science, cybersecurity, computer networking) or involves subjects that strategically complement research by the Unit, or the university as a whole e.g. medical science, computer animation, and assisted living. The growth of the Unit size has seen a sharp increase over the recent years in terms of new recruitments, but also in terms of promotions. The following table shows the recruitments:

	Lecturer	Senior lecturer	Principal academic	Associate professor	Professor
Dept. of Computing	19	8	2	2	2
Dept. of Creative Technology	15	7	5	3	1

The departments have been devoting significant effort in terms of strategic investment in recruitment and facilities to implement the Concordat set. Substantial investment was made in research funding and infrastructure to attract new staff. In addition to the investment, the Unit encourages network building and development of an excellence-focused culture in order to recruit high calibre staff.

BU is recognised as a Mindful Employer, actively promoting excellence, diversity and equality (<http://www.mindfulemployer.net/>). Its approach to the employment and career development of disabled individuals is recognised by the DWPs' award of Disability. Equality Diversity and inclusivity are key considerations running throughout all staffing processes. The Unit is committed to creating an ethical, egalitarian workplace that values its staff and supports all aspects of skill and career development.

2- Dedicated ECR support: The present REF submission of UoA11 relies on a cohort of researchers including 24% ECRs. ECRs have reduced teaching loads and are given sufficient time to establish their research programmes. Within a month of arrival, a research briefing by a senior colleague introduces them to the comprehensive support framework, including: assistance with grant writing, internal peer review, funding for equipment purchase, study leave, collaborations, and conference attendance, and also provides them with mentors. In particular, all new ECR staff have an academic advisor to mentor and guide them during their 12-month probation and during their early career period. In addition to regular meetings, a formal performance review takes place mid-way and near the end of the probation period. Specifically, all postdoc researchers (PDRAs), as a sub-category of ECR, are assigned an academic mentor to assist with career development. The Unit has employed 13 PDRAs during the REF period compared to none in 2014. All these actions to support researchers at the start of their research journeys are underpinned by the extensive Researcher Development and Knowledge Exchange Framework (RKEDF see REF5a), which supports a skills identification and training framework. The sum quality of the training and support early career researchers receive is evidenced by a strong record of them receiving employment offers from both academia and industry.

3- Staff Development: Significant investment in staff time has provided a carefully managed environment for research development, where each staff member has an allocation of time for research and professional practice (typically about 35% contract hours). This encourages staff members to develop and accelerate their research careers and develop influential research outcomes. To be able to secure a better staff development agenda, all staff are required to produce, on yearly basis, a Personal and Professional Development Plan (PPDP) which is presented and discussed with their Line Manager. The PPDP aims to track the progress of staff not only in terms of research but also in terms of education and professional practice.

Career development is embedded in the process of the performance review in order to identify development opportunities and support areas. This encourages performance benchmarking, recognition of achievement and guidance for addressing weaknesses that need to be addressed for promotion or development. The PPDP process is independent of, but informs, the annual salary review and promotions. In fact, salary review and promotion are based on applications when a formal interview with the candidate sheds light on strengths and areas of improvements. Unsuccessful candidates are supported at

the department, Faculty and University level, and are guided with a personal development plan discussed and agreed through the PPDP process which is very useful especially for lower-grade staff e.g. lecturers and senior lecturers. The number of promotions recorded during this REF period within the UoA11 is:

	Senior lecturer	Principal academic	Associate professor	Professor
Dept. of Computing	11	9	5	6
Dept. of Creative Technology	1	3	0	3

Moreover, a key criterion for the career development of PDRAs is to demonstrate research independence. University HEIF (Higher Education Innovation Funding of £30k pa) has been established to recruit PDRAs in order to begin collaborative projects. The Research Development and Support (RDS) Team regularly arrange sessions to encourage PDRAs to collaborate, develop new ideas and to find research partners.

In addition to department-based mentoring, BU through the Unit provides extra support e.g. seed-corn funding and investment; grant writing support from an external peer review panel; targeted help in matching researchers to appropriate funders (Research Professional) and potential collaborators; and staff training in specialist bid preparation. Bournemouth University also funds HEIF funded Research Fellowships for excellent researchers.

Bidding activity of UoA11 staff has increased by 295.74% over the REF period as a result of the awareness effort, incentives and recruitment policies. Staff engaged intensively with a number of initiatives to enhance bidding and success rates including training programmes, funder visits, and specialist external bid writing support.

All academic staff must undertake online training and development on research ethics, equality and diversity. All new academics are required to complete a Postgraduate Certificate in PhD Supervision. Experienced PhD supervisors must attend staff development refresher programmes every three years.

Sabbatical leave is dealt with and approved at departmental level – five colleagues have taken leave for a career break, secondment or further training during the REF period. We also encourage staff to undertake professional practice as part of their academic role.

- 4- Enabling staff mobility and networking:** As part of the Unit strategy, networking is a cornerstone, especially with industry. As indicated in Section 1, the staff have strong connections with industry as part of various research projects and collaboration. A number of KTPs (8, plus a set of 4 postponed) have been proposed and successfully executed. Moreover, many secondments of academic staff in industry have taken place, all of them were part of H2020 projects such as: INFER (Budka, Gabryz, Bakirov), IDEAL CITIES (Vasilis, Chechina, Ali, Kostoulas, Angelopoulos, Henriksen-Bulmer, Amelidis) and FIRST (Xu, De Vrieze). In addition, staff in UoA11 have strong collaboration networks (Please See Section 4 for more details on collaboration). These collaborations are diverse in terms of extent and scope (academic and scientific, industrial, training). Examples include: projects (PROTEUS, RABOT, SOCIAD, ECHO), research visits (20), training networks (Eduweb, Gamebiz, cLINK, FUSION), PhD studentships (23), and outreach activities (Festival of learning, Festival of learning in China, Bournemouth Air Festival). The Unit, via the departments, continues to financially support staff to attend national and international networking events to: 1) disseminate research, 2) build collaboration ties and 3) stimulate bidding activities. Within the CI department, industrial talks are regularly held by industry partners/guests to explore their collaboration potential with researchers and PGRs.

5- Staff support and recognition: The Unit, via the departments involved, recognises and rewards staff for carrying out research and for achieving impact through financial support (QR funding and university funding) and workload flexibility, as indicated earlier. UoA11 was allocated a QR budget amounting to £245,951 since 2014/2015 to support staff members, in impact and networking activities. The budget was part of £2,838,587 that was dedicated to enhancing the research environment in general including travel to events, equipment, outreach, co-production, hosting guests, etc.

In particular, The Unit engaged two PDRAs (one for supporting the impact and the other for supporting the output), in addition to the Research Development and Support dedicated members, to support staff to advance their research impact. Numerous training sessions given by renowned external guests during the whole REF period helped to explain and enable staff to achieve impact from their research.

2.2 Research Students

The BU Doctoral College in collaboration with the various faculties provided access to over £1,318,786.16 in match-funded PhD studentships and £853,524.60 fully-funded PhD studentships since 2014 and committed to fund 50 per year plus 50 doctoral (fee waive) scholarships per year. In this REF period, UoA11 earned 8 fully funded and 34 match-funded studentships in contrast to the period preceding 2014 which record only 2 fully funded and 7 match-funded.

The overall increase of the growth in PhD registrations (20%) compared to the previous REF period is due to both increased external and BU internal funding. A distinctive feature, enhanced by the match-funding model for BU studentships, is the number of PhD projects that are in collaboration with industrial partners. BU has invested in state-of-the-art PGR monitoring software (ResearchPAD, provided by Converis) and a dedicated administration team to support our PGRs is provided. UoA11 is taking full advantage of that securing the highest number of PhD awards across the faculty of Science and Technology.

- **Recruitment:** PhD studentships are advertised internationally via online systems, on the BU's website and through our research networks. Interviews include an independent professor, whilst gender balance is considered. New PhD student numbers have grown under different schemes (self-funded, fully-funded by BU, externally fully-funded through research projects). The annual PhD student intake of UoA11 has grown by 13% from pre-2014 to 2020.
- **Supervision and monitoring:** Students have up to three supervisors (one primary) and supervisory training is mandatory for all staff. A six-month review ensures that the student has a clear overview of their subject area and the steps required to complete their PhD. A 12-18 month major review (previously transfer to progress from MPhil to PhD), confirms there is a clear path to completion. PhD students have weekly meetings with their supervisors and are required to attend research seminars to learn from their peers and from guest speakers. All PhD students are expected to submit their PhD theses in three years with a maximum of four years. For exceptional circumstances, a special case can be made to the university for an extension.
- **Development and funding:** Development events, including induction, are offered by the Doctoral College based on Vitae's Researcher Development Framework. Students have access to funds to support research, conference attendance and placements (Doctoral Study fund, £3k per student over their PhD period). All BU funded PGRs are required to undertake at least two public engagement activities during their studies. The Doctoral college provides specialist skills training and knowledge modules, details of which are compiled for safety and training records. Departments usually top up the doctoral study fund if needed. Students that are deemed to require English tuition, identified through a rigorous test, receive the necessary help through the Language Support Unit [Bournemouth University languages community]. Health and Safety training e.g. fire safety is given and recorded, supported by the Departmental and Faculty Safety Officers.

- **Integration with the research community:** PGRs are part of the Department and Faculty research community. There is a PGR representative on the School Research Committee and all PGRs are invited to Research Centres/groups meetings and there are weekly research seminars given by PGRs and staff which PGRs are expected to attend. Moreover, Academic and Emotional support is provided through the Post-Graduate Tutors. There are university tutor and health-care professionals to assist where necessary. Interruption of studies can be made on health or compassionate grounds. Socialising among PhD student community is promoted by monthly PhD lunch and coffee-cake get-togethers.
- **Seminars and conferences:** Students hold annual Faculty-wide PGR conferences (including poster competitions judged by industry experts (<https://www.bournemouth.ac.uk/study/postgraduate-research/researcher-development/conferences-exhibitions-showcases>)) allowing PGRs to showcase their research and a popular monthly PGR Forum takes place in addition to biannual away day events.

2.3 Equality and Diversity

This Unit promotes equal opportunities and outcomes by adopting flexible working practices and supporting family and work-life balance, which has helped many staff (including staff with young children, staff with disabilities and staff returning from sick leave) to continue to engage actively in research. 24% of staff and 26% of outputs submitted in the Unit are from Black, Asian and minority ethnic backgrounds, which makes the Unit one of the most racially diverse at BU. Fast adoption to “working from home” mode since April 2020 has enabled the Unit to further embrace flexible working practices to benefit all staff. This ensured continuity of research activities to mitigate the impact of Covid-19, where remote supervision via virtual meetings and online collaboration platforms support all staff and PGRs.

BU is a member of the Athena SWAN charter and retained its Bronze Institutional Award in 2019. We are addressing the underrepresentation of female staff in the Unit (13% female, 87% male) and our recruitment strategy is designed to achieve a more balanced gender profile. The Unit has embedded gender equality in the recruitment process of PGRs and researchers. For example, all shortlisting and interview panels are gender representative and gender balanced wherever possible. Initiatives to further reduce traditional barriers to progress for women scientists in the Unit include focused writing retreats, inclusion in internal review panels and QR funding.

We schedule teaching loads to be congruent with caring responsibilities and extra-university requirements, via a transparent process, e.g. all departmental meetings are between 10am and 4pm, with our research seminars at 4pm.

Our institution offers a more generous maternity/paternity/adoption leave provision than required by law. Colleagues with parental responsibilities also have access to flexible and convenient childcare via on-site childcare provision for ages three months to 14 years. The on-campus nursery and pre-school (ages three months to five years, Ofsted Outstanding) runs throughout the year, and our Sport BU team run holiday childcare (ages five to 14) during the Easter, summer and Christmas holidays. Colleagues may request the use of QR or other internal funds for childcare whilst at conferences.

BU achieved Disability Confident status, a quality mark awarded by the Department of Work and Pensions, for our positive commitment to the employment, retention, training and career development of disabled employees. Its approach to the employment and career development of disabled individuals is recognised by the DWPs' award of Disability Two Ticks Status and *HR Excellence in Research Award*. Colleagues with disabilities (7% of submission) have benefited from the introduction of a full-time Faculty Health & Safety Officer (2017) liaising between the department and Institution, and from the Institution's work with 'AccessAble' to provide detailed access information for all buildings and facilities.

3. Income, infrastructure and facilities

3.1 Income

The success of our interdisciplinary approach and integrated research and impact strategies, coupled with world-class institutional research support (see REF5a), is demonstrated by a major uplift in annual research income from £296K in 2013/14 to £1.4 million in 2018/19 (see Figure 3) and a significant increase in awards from both UK and international funders (see Figures 4 and 5).

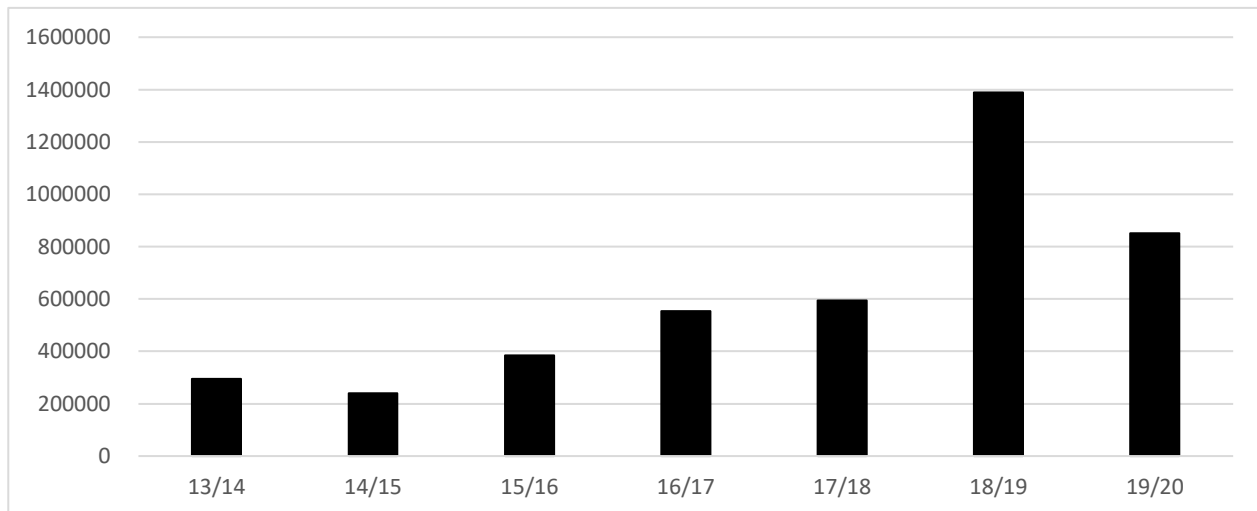


Figure 3. Increase in external income per annum for Computer Science and Informatics research at Bournemouth University

As a part of our Unit research strategy we deployed a huge effort on income generation in this REF period, supporting our ECRs and strengthening the research culture through various channels. This involved amongst other things active engagement as a Unit in various institutional development initiatives and support activities as well as internal competitive funding schemes for ECRs, pump-priming and knowledge exchange. This resulted in 67% of UoA11 staff submitted having been Principal or Co-Investigator for a research grant in the REF period, representing a huge step forward. Figure 4 represents the increase in UK research funding over the REF period which increased annually reaching a high in 2018/19. The impact of Covid-19 reduced predicted income in 19/20.

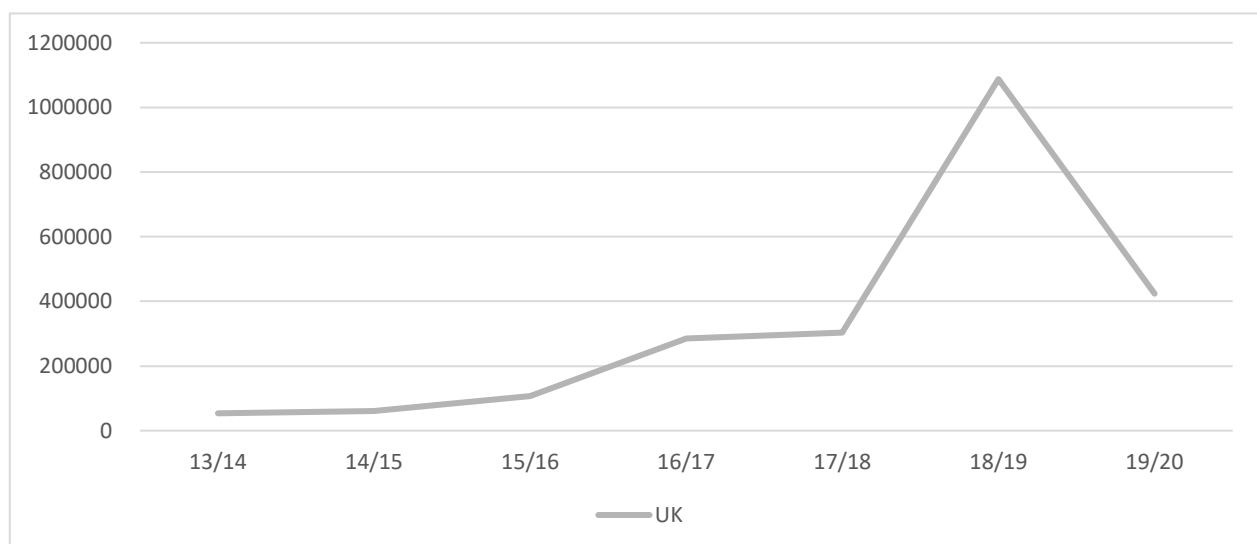


Figure 4. Increase in UK research income per annum for Computer Science and Informatics research at Bournemouth University

A significant amount of money has been invested in supporting research internally through a number of internal funding schemes focused on supporting income generation. These include those designed to inspire and equip researchers to achieve greater success with Research Council funding (Grant Academy - GA, £14,965.00), support for ECRs (Acceleration of Research & Networking – Acorn, £72K), Charity impact fund to support initiatives involving charities (£175,948.92), HEFCE funded support for business engagement and knowledge exchange ideas between HEI and the wider world (Higher Education Innovation Fund – HEIF, £2,017,248.00), Fusion fund to support internal co-creation initiatives (FIF, £435,762.40), and Research Impact Fund (RIF, £94,052.82).

UoA11 has taken full advantage of internal funding opportunities securing the following investment over the REF period:

GA	1,985.00
ACORN	8,999.04
Charity Impact	15,141.00
HEIF	414,610.00
FIF	31,995.00
RIF	11,850.00
Grand Total	484,580.00

UoA11's researchers have generated income through various multi/interdisciplinary consortia involving national and international partners. EU Projects, such as PROTEUS, INFER, IDEAL CITIES, FIRST, RABOT, SOCIAD, ECHO, Eduweb, Gamebiz, cLINK, FUSION, etc.), involve large consortia and cover interdisciplinary research in Big Data, Cybersecurity and Manufacturing. Figure 5 illustrates a stable increase in the international funding over the REF period.

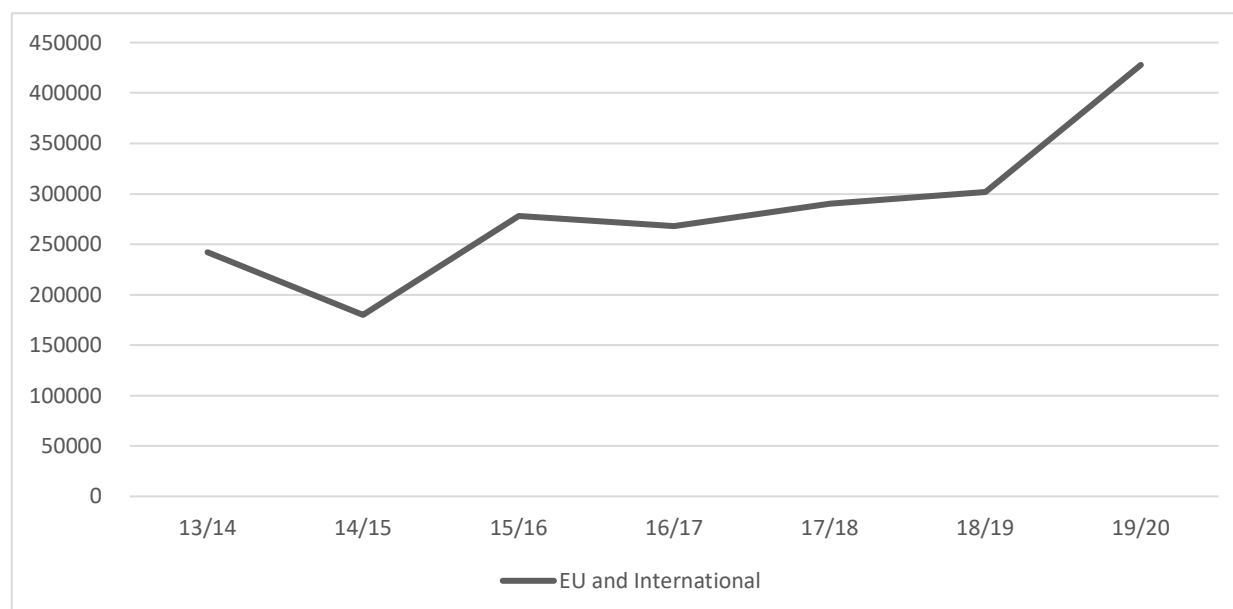


Figure 5. Increase in EU and International research income per annum for Computer Science and Informatics Research at Bournemouth University

Such projects have had a great impact on the research output totalling more than 100 publications in conference proceedings and high impact journals. Three of the Unit's impact cases also stem from these projects. A number of ECR (9) participated in the proposal and execution of such projects. The approach of the UoA11 consisted of involving as many ECRs as possible not only in the execution of such projects, but as co-investigators with full involvement in the writing of the proposals. All of the ECRs have submitted bids in the role of principal investigator.

This explains the increase of the number of bids submitted by the UoA11 over the last three years (up by 300%). While this figure is quite substantial, the actual increase in income was about 60%. Given the young history of UoA11 at BU during this REF period, the Unit's strategy has primarily involved motivating staff to engage in bidding and learning more about formulating proposals. The next step of the Unit's strategy is to refine the bidding action by placing more focus on increasing the success rate and income.

3.2 Infrastructure and facilities

The Faculty of Science and Technology has invested heavily in specialist and cross-cutting laboratories that are available to our academics for research purposes in order to cover some of the most impactful research themes: Cyber Security, AI and Data Science, Human Computer Interaction, Social Informatics and Software Engineering, Computer Networking and IoT, and Games Technology.

Specifically, the UoA11 acquired a CISCO Lab, Creative Studios and two cross-cutting labs – the Psychology Group's Interaction Lab and the Design Group's Electronic Lab with a combined total investment of £750k. The UoA11 invested ~£400k in two new state-of-the-art Forensics and Security Laboratories to support our research activities in Information Assurance and Cyber Security. Although these laboratories are primarily focused on Security, they are configured to support our other research activities, such as large-scale systems-of-systems engineering and Big Data analytics. A new building (Poole Gateway Building) has been designed to increase the collaboration between researchers from UoA11 and UoA32. Moreover, the university is planning a new building that will host the Department of Computing and Informatics as part of the investment into Computer Science and Information Technology.

UoA11 continues, with the support of the university, to improve its facilities considering two levels:

- a- **Internal:** BU continues to address the research needs by investing in research equipment as well as space. The department of CI will be moved to a new building that is equipped with modern facilities in order to create a better research environment.
- b- **External:** When necessary, BU staff are asked to use national facilities in the country. For instance, Computing staff (Bouchachia) has been using the high-performance computing infrastructure (Hartree Centre), owned by the Science and Technology Facilities Council, in order to run large scale simulations and big data analysis (distributed machine learning for Projects such as PROTEUS and HFADA (High Frequency Appliance Disaggregation)).

Moreover, UoA11 has been collaborating with RDS (REF 5a) to improve the research environment, technical research infrastructure and the delivery of projects. We have been working across all three RDS teams:

- Funding development team,
- Project delivery team,
- Knowledge exchange and impact team.

This allows us to continuously improve support to academic staff at all stages of a project lifecycle whilst observing equality and diversity across the board.

4. Collaboration and contribution to the research base, economy and society

Section 4. Collaboration and contribution to the research base, economy and society

As part of our impact-driven research, staff have established strong links to public administration, organisation, industry and charities in an effort to contribute to solving societal, industrial, and environmental problems amongst others. This has raised the level of commitment over the recent years in line with Fusion principles and BU2018 and BU2025 visions which emphasise the role of collaboration and knowledge exchange with industry and business as well as establishing long-term relationships in strategic alliances and across multidisciplinary themes.

As part of our long-term plans, UoA11 formulated a bidding strategy with a major focus on the EU's Horizon 2020 programme, the Global Challenges Research Fund and the Industrial Strategy Challenge Fund. These funds are industry-led; therefore UoA11 is nurturing long-term stable relationships with industrial organisations based on an exchange of ideas and with a good understanding of their domains needs. Currently, the Unit staff are collaborating with organisations such as BEIS (Government Department for Business, Energy and Industrial Strategy) and Dorset Clinical Commissioning Group (DCCG). In addition, collaboration with enterprises such as: BT, BAE Systems, Deloitte, JP Morgan, IBM, Microsoft, and Thales and with SMEs such as Boo9, Coeo, CudoVentures, Enzen, Famiio, Fidelity International, Hugslock, Inmarsat, LimeTools, Lush, NATS, PulseEight, Quayside and Katalytik, Renston, reignition, Roke, Royal Signals Museum, Sentinel, Shoppar, Solentim, Spharea, Tenable, Think.aero, Tripple Play, Wessex Internet, and YougoWorld have resulted in eight KTPs which have recently started. Four KTPs have been postponed due to COVID-19 with others in the pipeline.

Besides the initiatives for external bidding, and as highlighted earlier, UoA11 has targeted the established internal funds that are used mainly as pump-priming resources. To promote research, and to encourage and support Early Career Researchers, BU has established an ACORN Fund (Acceleration of Research & Networking). Two researchers have been funded under UoA11 with a total amount of £9000. In addition, the Charity Impact Fund is used to facilitate relationship development with charitable organisations or build on existing research collaborations. This scheme has allocated and awarded £175,948.92 to BU academics since 2014, with £15,141.00 awarded to UoA11 across five projects.

Moreover, UoA11 follows BU's vision about 'creating the most stimulating, challenging and rewarding university experience in a world-class learning community by sharing our unique fusion of excellent education, research and professional practice and inspiring our students, graduates and staff to enrich the world.' The achievement of this vision is supported through the Fusion Investment Fund (FIF) and in particular its Networking Strand which provides staff with the opportunity to develop and pursue their fusion goals by bidding for and drawing on these 'pump-priming' resources. FIF (networking) is part of BU's investment in intellectual capital. Through over 160 projects, the FIF has awarded £435,762.40, with £31,995.00 awarded to projects within UoA11.

One aspect of the Unit's research and impact strategy (see section 1) has been driven by:

- Reinforcement of the industrial links and collaborations: staff have established strong links to various SMEs and enterprises in the region, in the country and in the world. To strengthen this vision, the two departments aligned with the Unit have created a dedicated role "Industrial liaison" for building ties with the industry. This is now a channel to KTPs (12) and match-funded studentships (14, plus 7 in the year 2013/2014) as well as placement for our UG/PGR students.
- Links to other universities/charities/public administrations: staff are encouraged to work with various public organisations, charities and with their peers in other national and international universities. Section 1 showed a few collaboration examples that emerged from this effort.

The Unit has maintained and strengthened strong links with a broad network of partners and collaborators across the world: Asia (China, Japan, India, Vietnam); Europe (Germany, Spain, France, Italy, Sweden, Norway, Greece, Portugal, Denmark, Poland); North and South America (US, Canada, Brazil, Mexico); Africa (Algeria, Egypt, Nigeria) and Australia. These collaborations are diverse in terms of extent and scope (academic and scientific, industrial, training).

In terms of co-authored papers, the top 10 institutions collaborating with UoA11 are: Zhejiang University (49), University of Technology, Sydney (23), Northwest Agriculture and Forestry University (22), Tsinghua University (20), University of Southampton (20), Siberian State

Aerospace University (18), Shanghai University (18), University of Bradford (18), University of Canberra (18), and Xiamen University (15).

Moreover, we appointed 30 visiting researchers (including 6 international professors) during the current REF period with expertise covering our prominent research areas: cybersecurity, data science, social computing, software engineering, HCI, creative technologies. The goal was to support collaboration and enhance research activities within the Unit.

Many of our publications over the past decade have been well received, e.g., *Cache “less for more” in information-centric networks*, by Koong Chai, who received an award from the journal; *A survey on concept drift adaptation* by Bouchachia; *Elderly activities recognition and classification for applications in assisted living* by Yu; *A goal-based framework for contextual requirements modelling and analysis* by Ali; *Character-based interactive storytelling* by Charles. In addition, best paper nominations have been achieved at major venues. For instance, Hargood et al. had their papers; *Patterns of Sculptural Hypertext in Location Based Narratives* and *Intelligent Generative Locative Hyperstructure*, nominated as best papers in the 27th and the 29th ACM Conferences on Hypertext and Social Media. Hulusic et al. also had *VR Video Storytelling for Intangible Cultural Heritage Preservation* nominated as the best paper in the 16th Eurographics Workshop on Graphics and Cultural Heritage.

Editorial work, positions and measures of esteem: The quality of the research culture within this UoA is evidenced by the many external responsibilities held by academics during this REF period, including: (a) journal Associate/Guest Editors (Evolving systems and Network: Computation in Neural Systems, Sensors, Applied Soft Computing); (b) programme committee members of international conferences (Bouchachia, Chai, Ali, Katos, etc.), conference/workshop chairs (Bouchachia, Dagan, Ali); (c) co-chairs for top international venues in their respective fields; (d) memberships, fellowships and senior fellowships in main scientific associations such as IEEE, ACM, IET, IMA, Eurographics and others and (e) project evaluators (UK research councils: Ali, Budka, Bouchachia, Tang, Yu - European Commission: Bouchachia, Gatzidis - International funding institutions Sweden, Saudi Arabia, Czech republic, Chile, Belgium, Canada : Bouchachia). Furthermore, UoA11 academics have been invited to give invited lectures at leading UK Universities. Other staff members were invited to serve as guest speakers at international conferences (Bouchachia, Katos) and as members of international panels (Evolving Intelligent Systems Technical Committee of the IEEE Systems, Man and Cybernetics Society, the IEEE Task-Force for Adaptive and Evolving Fuzzy Systems and the IEEE Computational Intelligence Society, Bouchachia).

Often UoA11 research projects are disseminated within external media programmes. For instance, our research focusing on digital addiction, gambling (Ali) and assistive technology advancements for improving life for people with disabilities (Whittington, Dogan) received attention from BBC1, Radio Solent, BBC1 South Today, The Telegraph, Huffington Post, the Italian daily La Stampa, and Bournemouth Echo.

Summary:

Given the young history of UoA11 at BU (this is the first time to be submitted), we almost started from scratch shaping up the Unit by taking advantage of all training, funding, networking and outreach opportunities to improve the research environment at BU. We saw a very strong increase in various activities (size of the Unit, publications, bidding, inter/multidisciplinary research, connecting with industry), and there are areas that will need to be refined and strengthened as part of the natural process of growing the Unit to become well established. It is the strategy of UoA11, put in place at the beginning of this REF period, to follow an incremental approach, initially, by incentivising and motivating the staff to engage with different facets of research and with changing the research environment and embedding the research culture, followed by refinement and strengthening in a second stage. The achievements attained so far are really promising, especially in terms of changing the culture.