Faculty of **Education**
The University of Hong Kong

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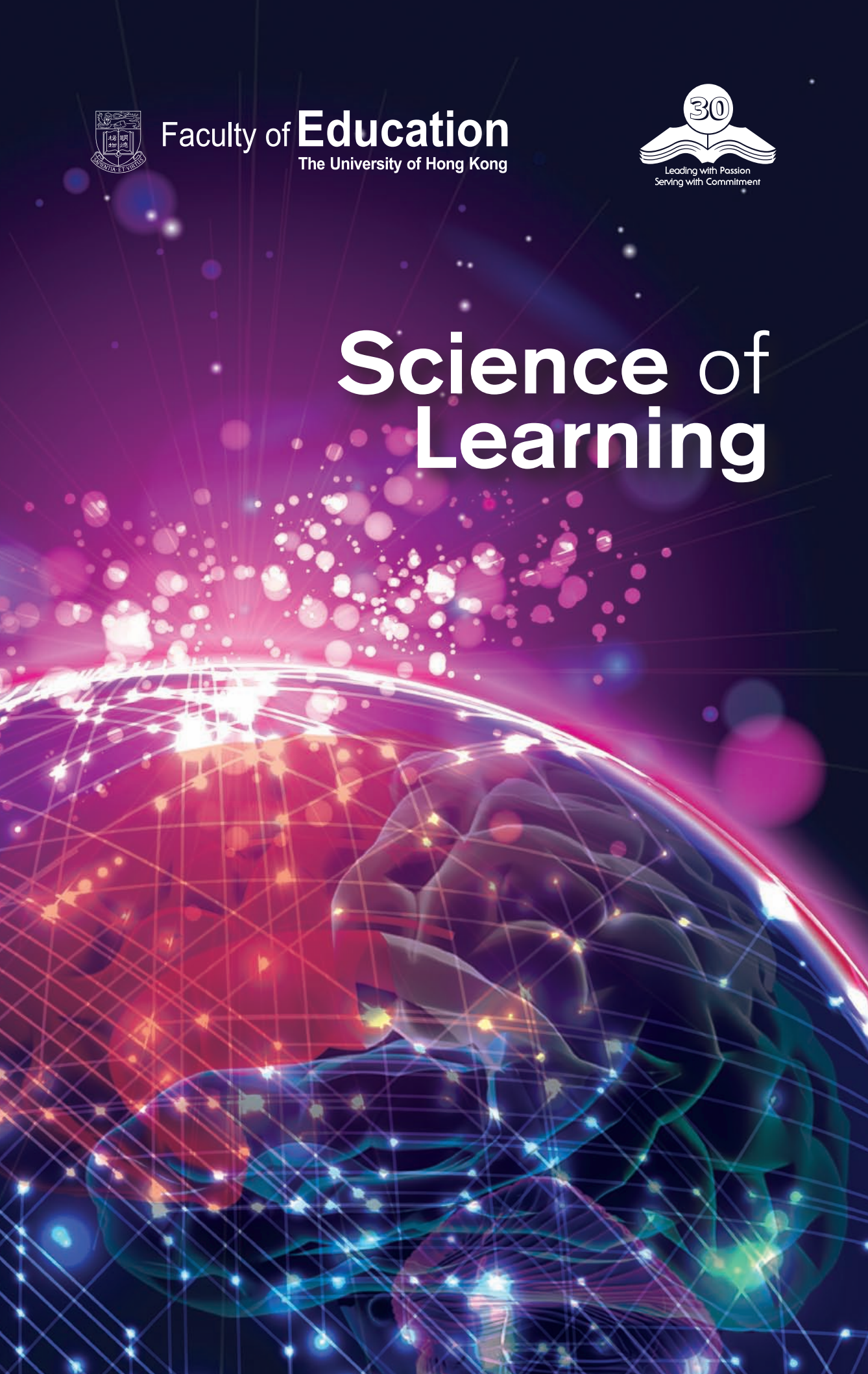
Leading with Passion
Serving with Commitment

Science of Learning

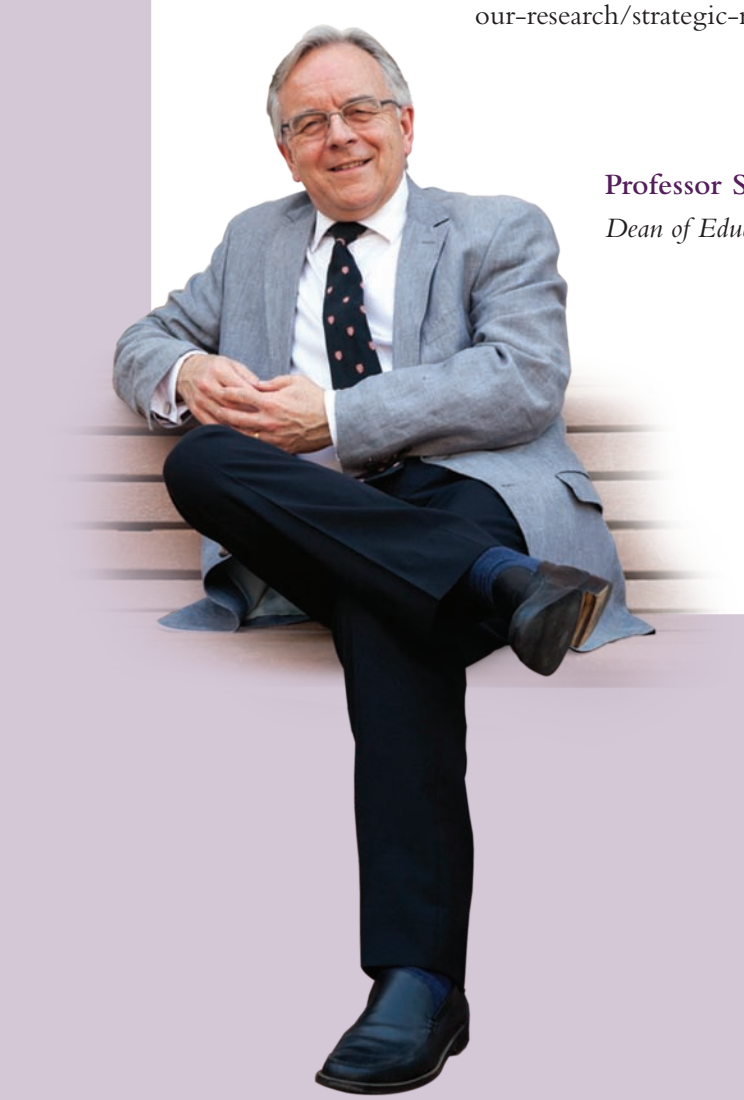


Dean's Message

The Faculty of Education at the University of Hong Kong is home to more than 100 international researchers from a wide range of disciplines spanning education, communication sciences and information sciences. This diversity of background and discipline results in a vibrant research culture. We proudly consider ourselves to be a nexus for the exchange and development of research that draws on the best of Asian (especially Chinese) and Western scholarship.

Within the many research themes addressed by colleagues in the Faculty, we have recently identified three common threads, which we have set out as our strategic focal research areas: the **Science of Learning**, **Education Policy**, and **Equity and Social Justice**. For each of these areas, we have produced a booklet, introducing the theme and also the scholarly work of some of our leading researchers in that area.

I very much hope that you will find these booklets interesting. If you would like to learn more about our research – in any of these areas or more generally - please visit our website at http://web.edu.hku.hk/research/our-research/strategic-research-focal-areas.



Professor Stephen J Andrews
Dean of Education

Science of Learning

Learning is a human instinct. In early childhood, we learn naturally (or "acquire") without intention. But before long, we come to learn by effort and by design.

For most of human history, except in philosophical discourse, learning occurred without much understanding of how it is we learn. Effort (by the learner) or the design (by the "teacher") were determined by cultural tradition or proven effectiveness.

Changes in social norms, human relations, means of communication, the pace of knowledge obsolescence and technologies create new demands on the nature of learning in the 21st Century. Thus, how people learn matters more than ever before. Recent scientific research has advanced our understanding of human learning, and challenges conventional wisdom about what are the most effective conditions for learning. Studies of learning have also revealed more brain plasticity in patterns of neural growth and decay than previously assumed.

Recent discoveries open new possibilities. Some learners have difficulty processing language due to poor temporal discrimination of sound. Such a discovery provides the basis for alternative diagnosis and programmes of intervention. The discovery of neural plasticity through to old age has led to improved programmes of rehabilitation.

Research results about the technology mediated learning of groups, organizations and communities, including the exponential uptake of social media, are no less spectacular. Network science has led social scientists and other related professionals toward an understanding of how, in times of crises such as epidemic or flood, communities and other social groupings come

together and act as an organized unity to alleviate catastrophes. Such studies have become the basis for improving crisis response for firefighters and other first responders.

Interdisciplinary research involving cognitive science, neuroscience, anthropology, computer science and statistics are contributing not only to a better understanding of how people learn, but also to the development of tools to support and measure learning and learner engagement under different social conditions.

The Sciences of Learning at the University of Hong Kong has become a Strategic Research Theme supported by researchers from the fields of education, neuroscience, psychology, communications, technologies, medicine, engineering, sports science and religious studies. It addresses significant problems in understanding the intricate array of patterns and processes of learning, while also conducting implementation studies and translation research to develop better strategies and tools to support learning. The respective scopes of research currently include early childhood development, language and bilingual learning, Chinese language learning, motor learning, learning and assessment technologies, and network models of collective behaviour for crisis management and orchestrating self-organized learning at the community level.

The University of Hong Kong's Sciences of Learning Strategic Research Theme continues to build global networks among researchers, policy-makers and practitioners across leading academic institutions and international agencies such as OECD and UNESCO.

For more information about Science of Learning at the University of Hong Kong, visit http://sol.edu.hku.hk.

Learning as a multilevel challenge for the 21st century

Professor Nancy Law

Corresponding Co-convenor, Sciences of Learning Strategic Research Theme, and Deputy Director of the Centre for Information Technology in Education, HKU

The potential of computers to transform learning and teaching was anticipated as early as the 1960s. But, while information and communication technology (ICT) has transformed much of our everyday work and social life, it has barely made a dent on learning and teaching, Twenty-five years of exploration into designing and promoting learning technology has led me and others to realize that changing learning in classrooms requires interdependent learning at teacher, school and system levels, and that we need new theories to connect learning at multiple levels. My research has focussed on this quest for a multilevel theory of learning that can guide educational policy and practice and ultimately prepare our younger generation for the knowledge society.

Research shows that adopting technology such as a simulation tool for student exploration of scientific principles or a discussion forum to scaffold learning through collaborative discourse requires fundamental changes in beliefs about how learning happens and the roles of learners and teachers. Identifying models of effective teacher learning has become an important research agenda.

Around the turn of the millennium, many countries, including Hong Kong, launched comprehensive education reform efforts that often include the use of ICT to support learning. This sparked much international interest in research on ICT-based pedagogical innovations. My investigations as a member of the International Steering Committee in the three Second Information Technology in Education Study modules (SITES M1, M2 and 2006) found that successful pedagogical innovations are often those which emerge as a result of concerted efforts from collaborative teacher teams in supportive school ecologies.

These findings challenge the traditional wisdom that innovations spread through the process of diffusion. There is much empirical evidence that innovations that sustain and scale are those supported by architectures for learning to foster behavioural change and learning across classroom, teacher and school levels interdependently. Architectures for learning are organizational structures and mechanisms for interaction and decision-making that scaffold communication, collaboration and alignment within and across different levels of the educational system that the innovation unit is involved.

These findings challenge the traditional wisdom that innovations spread through the process of diffusion.

Environments that support learning innovations and conditions that are conducive to their scalability have become an important research agenda for governments and supranational organizations such as OECD and the European Commission (EC). I was a co-investigator on the EC's Upscaling Creative Classrooms in Europe and Asia (SCALE CCR) Study, the goal of which was to identify the conditions for scalability of ICT-enabled learning innovations. Our study found further evidence that the scaling-up process of a learning innovation is an evolutionary process involving the entire multilevel education ecosystem. The exact starting point or the "level of innovativeness" is not important, as long as there are structures and mechanisms in place to support progressive and aligned learning and development at the various levels. We found parallels between learning at individual, organizational and system levels – change takes place progressively and there needs to be intentional efforts to support the learning as an evolutionary process to build multiple, interdependent capacities.

My current research on sustainable learning innovations is two-pronged. One strand is to develop indicators for assessing the level of change and scalability of an innovation through measures of organizational structures and interaction/decision-making mechanisms at different levels of the education ecosystem during the process of innovation implementation. This work is currently supported by a General Research Fund award and a Humanities and Social Sciences Prestigious Fellowship award from the RGC. The second strand is to develop (1) socio-technical designs for sustainable cross-school learning communities of teachers and school leadership teams to drive pedagogical innovations in classrooms, and (2) technology tools for learning design and learning analytics to support teachers and learners. This work is currently supported by a School-University Partnership grant from the Education Bureau of the Hong Kong SAR.

Starting blocks — the crucial early years

Professor Nirmala Rao
Serena HC Yang Professor in Early Childhood Development and Education, and Dean of Graduate School, HKU

Since the turn of the century, compelling evidence has emerged on the importance of early childhood education to a child's long-term growth and potential – evidence that suggests intervention in the early years is more effective and more useful than that later on in life.

Research on understanding early development and learning draws upon the fields of developmental psychology, education, neurosciences and economic sciences. This inter-disciplinary approach that is directed at improving developmental and learning outcomes is a hallmark of the field of *Science of Learning*. Indeed, it is these inter-related strands of research which have facilitated the building up of a full and rounded picture of the importance of investing in the early years of development.

Neuro-scientists have shown that the brain develops most rapidly in the first three years of life and is highly responsive to and affected by environmental stimulation. Programme evaluation research shows that participation in ECE promotes cognitive development and can narrow the achievement gap between children from low-income families and their peers from more advantaged backgrounds. The possibilities of more far-reaching outcomes are shown by economic studies which indicate that the returns on government investment are higher when the education investment is incurred in early childhood as compared to adulthood.

It's not just a matter of saying this works but actually looking at the implementation.

Our findings have been informed by work conducted not only through different disciplinary lenses – educational, economical, neuro-scientific – but also by the meticulous collection of good and wide-reaching evidence garnered through both meta-analysis and empirical work. For example, our research team has recently completed a systematic review and meta-analysis on the effects of early childhood inventions on cognitive development in developing countries for the British government.

We have also just completed a project funded by UNICEF to develop a tool to measure early childhood development and learning, the East Asia Pacific-Early Childhood Development Scales. This project, which involved assessment of over 8,000 children from Cambodia, China, Mongolia, Papua New Guinea, Timor- Leste and Vanuatu, has resulted in unprecedented data on early development in the region. Now countries have an appropriate tool which can be used to evaluate programme efficacy and get the best evidence of what works and why. Indeed, the emphasis around the world has been towards evidence-based decision-making, and this research is very important from that aspect since it bears on policy.

But what is really innovative is the way the research is moving from evidence-based programming to focussing on implementation science. The latter should inform the adoption, replication and expansion of evidence-based programmes and is particularly needed in the Asian region. The next phase, currently underway, is to scrutinise the programmes that are really effective and understand why and how they work. It's not just a matter of saying this works but actually looking at the implementation. We need to focus on understanding how (in)effective programmes are implemented and on understanding the processes through which early childhood programmes affect child outcomes.

Cognitive processes in language learning and speech production

Professor Brendan Weekes
Chair of Communication Science, and
Director of the Communication Science Laboratory, HKU

Within Hong Kong and the South East Asian region, the Division of Speech and Hearing Sciences (DSHS), plays a leading role in linguistics research, employing neuroscience methods to understand speech production and problem-related speech pathology. In Hong Kong's multi-lingual environment – where many speak Cantonese, English and Mandarin – a particular area of study is cognitive differences involved in speaking Mandarin and English. Some thinking suggests that native mono-lingual Mandarin speakers and native monolingual English speakers process language in different ways.

Our research reveals more convergence than divergence, but that the age of acquisition of a second language is significant. The older the person, the more divergence there is, the younger the more convergence. But at any age the language environment – bilingual versus monolingual – is a vital factor. Early bilingualism leads to cognitive advantages over the lifespan. Bilinguals when compared to monolinguals are faster at information processing and conflict resolution in non-verbal tasks. Incredibly, these effects are already present in bilingual infants.

The field has seen growth worldwide over last 20 years, and has really taken off in the last decade.

Monitoring of the brain to see which areas are used in language learning has found that there is a "language muscle" that is exercised more by bilingual speakers. The bilingual experience strengthens the executive control network creating more connections between brain areas of this network.

Since with learning brain changes occur, if bilingual speakers are using that "muscle" more, there will be a knock-on effect for other learning outcomes.

As well as immediately obvious benefits, bilingualism has other longer – term advantages for healthy ageing. Our laboratory was the first to show that bilingual seniors, aged 50-plus, have more grey matter in the left temporal lobe of the brain. Since the cognitive reserve is greater in bilinguals, it can delay dementia by up to five years.

Our work on cognitive process also has implications for children with reading problems such as dyslexia, maths problems (dyscalculia), and comprehension problems associated with autism and dementia, and we have made important discoveries on exactly how brain damage (aphasia) affects bilingualism.

The field has seen growth worldwide over last 20 years, and has really taken off in the last decade. Centres have been set up in key universities around the world, and the DSHS collaborates with many of them including Cambridge, UCL, Oslo and Penn State.

The most significant research problem we are tackling is to perform cross-linguistic studies comparing linguistically distant languages such as Indo-European languages (Hindi, Persian, Russian) versus Ural-Altaic languages (Turkish), African languages and isolated languages spoken in remote areas of the world (Papua Guinea, Amazonia). Apart from providing us with general rules for the organization of the bilingual brain and the management of bilingual aphasia, such studies may provide a glimpse into the evolution of the human brain and language processing.

Inter-disciplinary insights into learning via inter-actional research

Dr Susan Bridges
Associate Professor, Centre for the Enhancement of Teaching and Learning, HKU

Higher education research on the student learning experience has drawn heavily on student and faculty perception studies. Our interdisciplinary team studying problem-based learning (PBL) in undergraduate health sciences is drawing on the strengths of our respective paradigms (educational sociology, educational psychology, sociolinguistics and health sciences education) to create new forms of collaborative, inter-actional research. The team's goal is to explore *Science of Learning* questions about learning across multiple levels of scale.

Recently funded under Hong Kong's General Research Fund, we are excited to undertake HKU's first cross-faculty (Medicine, Dentistry and Speech & Hearing Sciences) educational research project on PBL in health sciences education, and to be the first to extensively apply a video-based, inter-actional approach in this field. Our goal is that, through our interdisciplinary teamwork, each specialist will contribute particular knowledge to create new trans-disciplinary understandings of fundamental phenomena involved in learning and curriculum design.

Our discipline-based co-investigators are fascinated by the analytic moment when a student's or group's thought processes become visible through the methodology.

A core focus is our common interest in the role of educational technologies for 21st century learners in clinical education. The team's respective hands-on experience in designing and implementing technological innovations (learning management systems; interactive whiteboards and plasma screens; video patient cases; mobile devices; online, asynchronous PBL) has further stimulated our research interest into their effects on student

learning. A recent systematic review on educational technologies in PBL in health sciences indicated few empirical studies in the field, but found trends that such technologies can support the development of medical expertise through the accessing and structuring of expert knowledge and skills, and by making disciplinary thinking and strategies explicit.

A key question we have been exploring at HKU is the consequential and cumulative nature of learning in PBL contexts. Our work to date has been mapping the inter-actional processes in which students are creating and constructing knowledge. In doing so, we have been able to establish the consequential nature of technology-infused designs to knowledge building across events within a single problem cycle. The challenge we are now taking up, with support, is one of scalability. We seek to explore how learning occurs over time, i.e. across the years of an integrated health sciences curriculum, and across contexts, i.e. from PBL discussions to clinical reasoning. In addressing this phenomenon, we aim not only to build new theoretical understandings of PBL in an information-saturated age, but also to address practical, applied issues regarding PBL facilitation, curriculum design, evaluation and research design.

Methodologically, our team's adoption of an Inter-actional Ethnography (IE), first developed at the University of California, Santa Barbara (UCSB) in primary school literacy studies and now found in diverse educational research areas, is novel to health sciences education. With its foundations in educational ethnography, IE analysis offers opportunities to address two limitations often associated with qualitative methods – scalability and direct evidence. Drawing on a video archive of PBL interactional data, the IE methodology will enable systematic documentation of classroom discourse with analysis enabling us to trace and map how PBL collaborative knowledge building is consequential to clinical learning. Our discipline-based co-investigators are fascinated by the analytic moment when a student's or group's thought processes become visible through the methodology.

Such collaborative research provides a dynamic paradigm of looking at the same phenomena from different angles so that we can systematically bring forward the ways of thinking about and talking about what each discipline sees in order to uncover the layers of work that students do. The potential of our analyses is to make visible what is often invisible or taken for granted, and build both inter-disciplinary and trans-disciplinary understanding of fundamental phenomena and processes of learning.

Navigating complex learning systems

Professor Liaquat Hossain
Programme Director of MSc in Library and Information Management, HKU

Complex Systems Research is a multi-disciplinary field, which seeks to understand the flow of information in both hierarchical and non-hierarchical systems to work out how they function, where the weaknesses are and how to develop and adapt them to improve information flow. It has applications for exploring multi-jurisdictional coordination challenges for dealing with large-scale disasters related to food, animals or humans, as well bio-security related threats such as the spread of infections, and crises related to flood, tsunami or fire, as well as humanitarian related disasters.

In solving these problems, it is not adequate to rely on the government hierarchical systems alone. How the government agencies, such as police, fire-fighters or medics, come together to respond to large-scale crises is just part of the picture. There is always a time delay – by the time the government has detected the signals and provided responses, a lot of catastrophic damage has already occurred. With today's social media, the community is often one step ahead. There is a lot of public information available and people use different types of media – Twitter, Facebook, chat engines etc – to propagate and share information.

How people take different signals from the environment, how they adapt to those situations and how they improve their response strategy.

To learn from these, there is a need to develop a platform for extracting information from community-based, public networks and to develop computational capability to put both sides of the information – the government response and the community response – together. In collaboration with

authorities in Australia, for example, our research is focused on investigating large-scale bushfires – how the fire fighters become engaged with the local community and provide safety and recovery efforts, and how different systems and groups of people interconnect with and are interdependent on each other.

We have developed a very large computational learning laboratory grounded on network science, termed a learning hub, to extract patterns of behaviour, represented by a network structure, and look at the evolution of how these groups of actors start working together, and how they emerge as a collective team. We can then make use of this information to improve crisis-response. This is not classroom learning. It is solving complex problems that the world and society are facing. Uncovering how these complex systems work gives rise to many computational challenges including how to understand the emergence of collective behaviour in real time and how to then begin to understand what are the most effective patterns of behaviour for dealing with different kinds of crises. The picture is necessarily wide-ranging in scope. The methodology studies evolution within the time period of the crisis. How people take different signals from the environment, how they adapt to those situations and how they improve their response strategy.

My work in this area includes theoretical and methodological explorations of the effects of social networks and technology in supporting communication flow during crisis, coordinated interventions and delivery of health care and sociology of health, coordination of communication flow during crisis, coordinated interventions and delivery of health care and sociology of health, coordination of public health interventions, social networks in allied health service learning, effects of social networks in the delivery of nutritional health outcome.

Subsequent to my recent work on "Connecting the Dots of Global Ebola Spread", I am leading a project in the region to study the coordination challenges in dealing with biosecurity threats involving both the robust functioning of hierarchical command control structure and the evolving community structure through social media. The goal is to develop an early alert system for the spread of infections, including through the collection and analysis of big open data, and to study the vulnerability of hierarchical systems for dealing with new emerging outbreaks using simulations. This work includes developing a keyword dictionary that will embed HK and Chinese contextual situations, and new approaches for search query and correlation analysis.

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