BenQ DISPLAY

Active Learning in the 21st Century Classroom

Increasing learning efficacy using interactive technology

A joint project with University College London and Oxford University

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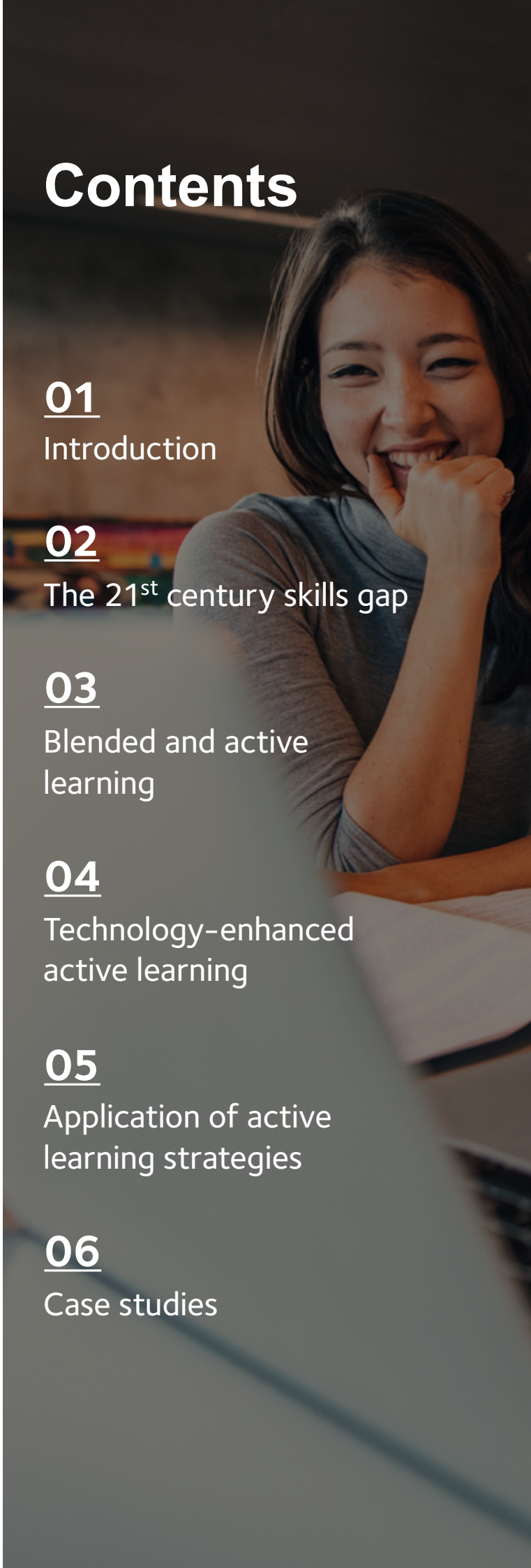

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01 | Introduction

Educational institutions are at a crossroads. They have reached the point where maintaining the status quo is no longer prudent. Their curricula must be able to adapt to the challenges posed by Industry 4.0 or risk producing graduates that lack the adequate skills and knowledge required of them to thrive outside of the university.

Industry 4.0, a term coined by the World Economic Forum founder and chairman Klaus Schwab, refers to the Fourth Industrial Revolution—an era characterized by innovations in the digital space.[1] This covers areas like artificial intelligence, robotics, cyber-physical systems, social media, and the internet of things. As with the first three waves of industrial shifts (Industries 1.0 to 3.0), these innovations directly affect the way people live, learn, and work. Previous models for business and education that may have been effective during one era, become obsolete with every ushering of a new era.

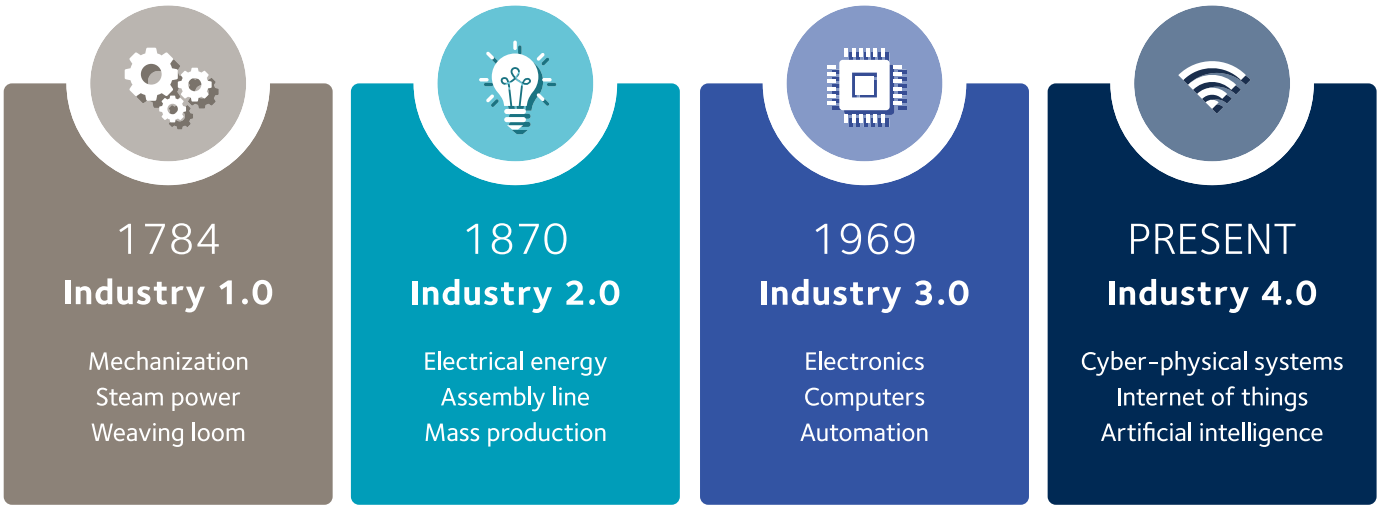

Figure 1. Timeline and change drivers of the four industrial revolutions

The systemic changes emerging from Industry 4.0 are unprecedented in their speed, scale, scope, and complexity. This fundamental paradigm shift caused by technology and digitalization is creating profound societal changes for governments, industries, businesses, society, and academia.

Innovations from science, technology, engineering, and mathematics (STEM) fields are prompting new working models in industries. The proliferation of modes of production are enabling businesses to operate with much higher efficiency and profitability. For instance, the ubiquity of mobile internet and cloud technology are allowing people to carry out synchronous work irrespective of geographical and linguistic barriers.

As the education sector strives to equip graduates with the proper skills to excel in the 21st century job market, there is a rising demand for institutions to reevaluate their current pedagogies. The reason underlying such a demand is an apparent skills deficit among university graduates. To address this global skills gap, institutions are reflecting upon questions such as whether their curriculum is agile enough to meet industry demands? Are the teaching styles of their staff suitable? Are their classroom technologies up-to-date? These questions guide the remainder of this research paper.

02 | The 21st century skills gap

The current pace and scale of Industry 4.0 are putting pressure on the business and education sectors to better equip employees and students when it comes to skills training. According to the World Economic Forum's 2016 Future of Jobs report, nearly 50% of the domain knowledge that students acquire during their first year of a four-year technical degree gets outdated by the time they graduate.[2] Education and training must be both future-proof and agile.

Schwab states that "New technologies will dramatically change the nature of work across all industries and occupations."[3] The fact that technologies can be leveraged to drastically increase the efficiency of the global supply chain through higher production volume and faster provision of goods and services, while reducing the number of employees, has great implications for the job market. He illustrates:

> ...compare Detroit in 1990 (then a major centre of traditional industries) with Silicon Valley in 2014. In 1990, the three biggest companies in Detroit had a combined market capitalization of $36 billion, revenues of $250 billion, and 1.2 million employees. In 2014, the three biggest companies in Silicon Valley had a considerably higher market capitalization ($1.09 trillion), generated roughly the same revenues ($247 billion), but with about 10 times fewer employees (137,000).

> The fact that a unit of wealth is created today with much fewer workers compared to 10 or 15 years ago is possible because digital businesses have marginal costs that tend towards zero.

His main concern is that automation, specifically robotics and machine learning, will eventually phase out particular skillsets or replace them with completely new ones tied to modern technologies.[4]

Some of the job skills that are deemed to be in-demand are revealed in the Future of Jobs report. Occupations that formerly relied on mainly technical skills now require more creative and interpersonal skills. Around 36% of future jobs across all industries will call for more complex problem-solving as one of its required core skills. This is compared to the projected 4% that only involve manual skills such as physical strength. When employees are unable to meet these changing needs, it creates a skills gap.[5]

The unpredictable impact of Industry 4.0 on the future job market will require people to be upskilled outside of their domain expertise. Furthermore, they will also need to proactively and continually undergo life-long training for novel forms of work that do not yet exist. This generates a competitive job market that puts some university graduates at an advantage: those who are well-equipped to step up to the challenge of tackling complex problems and are quick enough to adapt to changes in the rapidly evolving landscape.

At the same time, universities face mounting pressure to ready graduates for the workforce. Traditionally, educational curriculum design has been content-driven and focused on imparting knowledge through memorization. However, employers in various sectors are coming to realize that this mode of domain knowledge transfer is insufficient. For this reason, the education sector is no longer solely focused on developing their students' hard skills and formal qualifications; they now also aim to teach soft, practical, and social skills that will allow students to apply their knowledge in order to thrive in the 21st century workplace.

In an effort to standardize what we now know as 21st century skills (the skills required by today's changing workforce) a consortium of academics, government bodies, and three major technology companies (Cisco, Intel, and Microsoft) formed the Assessment and Teaching of 21st Century Skills (ATC21S) initiative.[6] Through rigorous reviews of related literature, the group was able to develop a comprehensive list of 21st century skills and how they can be taught and assessed. They proposed a framework—

independently evaluated for its validity and applicability in a pedagogical context—that systematically categorized these skills and competences into four groups which they deemed essential to present and future jobs.

Table 1. Pedagogy-relevant 21st century skills in higher education

Category	Skills	Graduate profile
Ways of thinking	• Creativity • Innovation	• Open to new ideas; incorporates diverse perspectives into their work • Creates new concepts or improves existing ones by analyzing, refining, and elaborating their own or other people's input
	• Critical thinking • Problem solving • Decision making	• Exercises reason when faced with different situations • Analyzes complex ideas and identifies outcomes, allowing them to make sound judgements and decisions • Open to viable solutions to problems and able to balance their own reasoning with that of their colleagues'
Ways of working	• Communication	Uses different modes of communication (written, oral, non-verbal) to present ideas, negotiate terms, and persuade others effectively
	• Collaboration	• Interacts effectively with others by communicating clearly, listening with care, and conducting themselves appropriately • Manages projects involving teams with diverse views effectively
Tools for working	• Information literacy	Able to find, access, process, and critically evaluate information to find innovative solutions
	• ICT literacy	• Uses and manages ICT applications effectively • Applies technology to conduct activities ethically and legally

Category	Skills	Graduate profile
Ways of living in the world	• Life skills • Career skills	• Can adapt to change • Able to work independently • Manages social interactions effectively
	• Personal responsibility • Social responsibility	• Communicates constructively • Exudes confidence • Exercises empathy • Understands conflicts of interest • Appreciates cultural diversity

According to the ATC21S survey, UK employers who recruited from British universities were more likely to be satisfied with their graduates' skillsets than that of new hires recruited elsewhere. They put more emphasis on soft skills over domain knowledge, stating that they were most satisfied with how the graduates demonstrated teamwork, problem-solving, and interpersonal skills. They did note, though, that they still found that several graduates were lacking in areas like commercial awareness, resilience, and negotiation. Given this, universities must take these 21st century skills into consideration when designing their curricula. By incorporating pedagogies such as blended and active learning approaches, they can narrow the overall skills gap and help their graduates meet the needs of the modern workplace.

03 | Blended and active learning

In a 2012 report by Norman Friesen, who collated the various ways the term has been used since its emergence in the late 1990s, "blended learning" can be defined as a form of learning that involves the combined use of online and digital media with physical modes of face-to-face teaching.[7] For the purpose of this research paper, we borrow this definition and narrow it down further by focusing on how it intersects with "active learning".

The common, passive way of learning mainly relies on students' ability to absorb information delivered to them through lectures or details they read in course material. It provides little to no scope for interaction and mainly promotes comprehension and memorization of information, which are skills at the lower end of the learning spectrum. Active learning, in contrast, focuses on developing students' higher-order thinking skills, which include the evaluation and analysis of data and other 21st century skills. It is any mode of learning that goes beyond passive acquisition of information. Research has shown that active learning can help students achieve a far deeper understanding of a topic compared to merely listening to lectures or reading textbooks.[8,9]

In order for active learning to take place, two-way communication must be established between educators and their students. The curriculum must involve activities that would allow students to participate by formulating and asking their own questions, exchanging ideas with their peers, and testing the knowledge they acquired through experiments and practical applications. Teachers can modify the activities based on the discipline or specializations that they teach.

Table 2. Differences between passive and active learning

	Passive learning	Active learning
Role of teacher	Provide and explain course material through lectures	Stimulate critical thinking through activities built around course material
Role of student	Comprehend and memorize information	Formulate and raise new ideas based on acquired information
Core activities	Listening and reading	Data analysis, debate and discussion, experimentation, and practical application of ideas

The flipped classroom structure is a good example of how blended and active learning are currently being applied in schools. In a flipped classroom, what would be considered as in-classroom activities, such as information dissemination through lectures, are done outside of the classroom, while take-home activities such as projects and worksheets are tackled during classroom sessions. Course materials are made accessible online, and students can either read the text or watch videos beforehand to acquire the basic information they need in order to contribute to the discussion.

Having this kind of structure allows teachers to use their classroom time to further process lessons with their students. Teachers can give students problem-based activities which they can co-explore in pairs or larger groups. This approach combines synchronous and asynchronous modes of learning that are delivered through the purposeful use of technology.

Table 3. Application of blended learning to synchronous and asynchronous forms of learning

	Synchronous learning	Asynchronous learning
What is it?	A mode of learning where students converge at the same location or online channel to learn at the same time; this is often teacher-paced	A mode of learning where students can access course materials and learn at their own pace
How is blended learning applied?	• Students can access online course materials beforehand to prepare for the lecture • Students can call in remotely via video conferencing or visit an online channel to participate in the lecture • Teachers can facilitate timed examinations which students can take simultaneously	• Students can access and study course materials that are stored as text and multimedia files online • Remote students can consult their teacher or peers through email, forums, video conferencing, or instant messaging • Students can take self-paced exams or complete online projects

Given how active learning equips students with the necessary 21st century skillsets they can readily use as professionals, this approach has risen in popularity over recent years. With this shift comes the call for university educators to adopt it accordingly. It is necessary for today's educators to incorporate more active learning opportunities to what would otherwise be largely lecture-based curricula. In a sense, they would no longer be just lecturers who transfer information to students. They would become facilitators and mentors who enable learning via student-centered activities, many of which require the application of learned concepts such as projects, case studies, debates, group discussions, workshops, and role-playing scenarios.

04 Technology-enhanced active learning

To apply the blended learning approach in the curriculum effectively, educators seek different ways of adopting digital technologies in classroom-based activities. The rationale for focusing on activities in physical classrooms is that, despite the growing popularity of online learning courses, particularly where professional qualifications are concerned, the majority of courses offered in the UK across primary, secondary, and higher levels of education still take place inside classrooms. As such, it is most beneficial for educators to think in terms of campus- and classroom-based activities when considering approaches and technologies that will enhance their students' learning experience.

Structuring lessons with presentation technology

Instructors have long since used presentations as a delivery method and key teaching technique in classroom settings. Presentations can be delivered using different media such as slides, websites, podcasts, or videos. These modes of delivery engage students through passive listening, reading, and watching. On their own, they do not encourage higher-level thinking as students are mostly busy trying to keep up with the pace of the narratives being relayed to them rather than critically and creatively forming their own views on the subject matter.

The traditional way of turning a presentation from a passive learning process into an active one is to encourage dialogue between the teachers and students, and among the students themselves. For example, the teacher can prompt the students to answer questions or ask questions during the presentation. When students answer questions, the teacher can gauge their level of understanding and use that opportunity to correct misconceptions. The process also helps students prepare for real-world, professional settings, where speaking up—whether in a small group or large audience–and other related social skills are required. These skills can only be perfected with ample practice. The teacher can also ask students to work in groups to solve problems. Group discussions often stoke student interest and engagement as they get to discover different perspectives through dialogue.

Slide presentations have become a common medium that educators use to present narratives in class. They not only serve as visual aids for concepts, but also give narrative structure to lessons and can be used to set up in-class activities.

With the emergence of Microsoft PowerPoint, slideshows have become easier to create, more accessible, and visually appealing. Based on estimates from both industry and academic sources, PowerPoint currently holds the majority of the global market share in terms of presentation software. This is partially due to the suite being the default software package used by educational institutions.

Other reasons why slide presentation is highly popular include:

Portability of content, which refers to the ease with which content from word-processing documents and datasheet files can be copied to a PowerPoint presentation;

Multimedia support, which refers to the ease to add text, graphics, links, animation, videos, and sound for more stimulating presentations. The addition of multimedia allows students to visualize and experience concepts that otherwise would be too abstract to articulate;

Ease of sharing, which refers to how presentations can either be easily transferred electronically, printed as physical copies, viewed on digital devices or transmitted through display equipment (both interactive or non-interactive displays) or webcasting programs (e.g. as Blackboard Collaborate).

Benefits aside, one of the weaknesses of using PowerPoint in teaching is that it tends to decrease active participation in class. When students are relieved from notetaking and are relegated to passive listening to lectures or reading information off slides, their attention can easily drift to other things. This phenomenon is called the "death by PowerPoint" syndrome. Freeing students from the burden of notetaking does not automatically shift their focus to comprehending the information presented to them; they must also be encouraged to participate.[10]

Educators can circumvent this issue by providing their presentations beforehand. Students can then study the material and acquire the basic knowledge they need in order to actively engage in discussions. With this method, presentations do not merely serve as visual aids that teachers project in class, but become the knowledge foundation that facilitates student engagement.

Furthermore, if their technology allows for it, educators may video-record their presentations, which the students can then revisit afterward. These materials can be particularly useful for students who may have difficulties expressing themselves verbally, whether they are studying in a second language or perhaps have a reserved personality. Students who have special needs, such as those with dyslexia, may also find recordings useful as these allow them to revisit anything they may have overlooked during the discussion.

As a teaching best practice at University College London (UCL), instructors are required to make slide presentations available to students at least 24 hours before each class. Classrooms are equipped with large pull-down projection screens which teachers can readily use for presentations. Some rooms have Lecturecast—a tool used to schedule and record lectures, as well as disseminate them to class participants. When such strategies and tools are employed in the classroom setting, students have more freedom to exchange ideas, which in turn leads to a better and deeper understanding of the lecture.

How can schools adopt blended learning in their classroom setting?

Learning and teaching spaces must be able to integrate physical and digital tools that enable blended approaches.

Default classroom technologies

Core teaching technologies normally provided in the classroom include desktop computers or laptops and projectors. Wireless internet is also essential for both teachers and students during classroom discussions.

Projectors and screens

Active classrooms which have digital screens are now increasingly common. Depending on their physical size and shape, multiple repeater screens or projectors can be found in the classroom to ensure that students can see the screen regardless of where they are seated.

Whiteboards

Whiteboards are key to active learning in the classroom. Although they are not technologically advanced, they bring major benefits to the classroom by offering students a space to work on.

Students can take advantage of whiteboards to visualize their learning through mind maps, brainstorming lists, and schematic diagrams. Student groups can also use whiteboards to draft ideas and receive immediate feedback from teachers or peers. They can then take photos of their work and further develop ideas outside the classroom.

Enhancing teacher–student dialogue through student response systems (SRS)

Teacher–student dialogue is a vital part of active learning in the classroom.[11] For classes held in large lecture halls, where the number of students is disproportionately higher than teachers, meaningful two-way exchanges are difficult to initiate. Lectures become one-sided not because teachers do not want to engage students individually, but because doing so would be impractical and too time-consuming. In situations like these, student response systems (SRS) and group response systems (GRS) are useful.

SRS and GRS technologies can enhance teacher–student dialogue by facilitating pedagogical strategies that were not feasible previously. These systems, if implemented correctly, can be used to transform traditional lectures into two-way learning experiences that involve active communication between teachers and students. Educators can deploy SRS and GRS using a variety of available electronic voting tools. These tools may be hardware-based, cloud-based, or hybrid systems that require both hardware and online platforms to gather and collate live feedback.

Electronic voting tools such as clickers are particularly useful in large teaching sessions where it is impractical to always interact with students on an individual basis. As its name implies, clickers are handheld devices that allow students to respond to questions by clicking options in a set of multiple-choice questions. This form of electronic voting helps teachers collect and analyze student responses in real time so that they can quickly gauge and adjust their teaching pace to match the level and speed of student comprehension.

Clickers also collect quantitative data anonymously. In smaller lectures where there may be students who have difficulty in openly expressing their opinions—whether caused by physical or social factors—clickers become an easy and effective way to get them to actively participate.

In lieu of physical clickers, teachers can take advantage of cloud-based SRS such as Socrative, Kahoot!, Mentimeter, and Sli.do to create polls and quizzes that students can answer using their personal laptops, tablets, or smartphones. Tools like Poll Everywhere, for example, allow teachers to embed the live results of their question-and-answer sessions into their

ongoing presentation. Every time they pose a question to the class, the responses are projected in either graphical or text form. Based on the results, teachers can either further clarify and expound on noteworthy points or move the discussion forward. Students can also anonymously send in their questions and comments through the interface so that the teacher can clarify any points of confusion.

Educators can also use SRS to gamify learning. Socrative, for instance, has Space Race, a customizable quiz where students form teams that compete against each other to finish first. Strategies like this make learning student-paced, as the length of their classroom session is dictated by how quickly they can apply the newly acquired subject knowledge.

At UCL, the Faculty of Engineering Sciences regularly employs SRS in lectures, tutorials, workshops, and conferences. The consensus from students' feedback shows that SRS has increased student interaction and improved teaching effectiveness.

Using clickers at UCL

When designing lectures, Dr. Elinor Bailey, senior teaching fellow in Physics and Astronomy at UCL, reflected on her own experiences.[12] As a student, she used to lose concentration while following lectures and would simply take notes and studied them afterwards.

To address this problem while teaching her own classes, Dr. Bailey made sure to incorporate activities that fostered teacher-student dialogue into her lectures. She used clicker technology for recitations and quizzes, which allowed more students to actively participate rather than passively listening to the answers of a select number of peers. For very difficult concepts, she would put students in pairs and ask them to explain things back to her after letting them discuss ideas with each other.

Moreover, she would let students digitally and anonymously raise questions during lectures. She would give students time to formulate questions or take notes before moving on to the next slide.

Since implementing these activities, she has received overwhelmingly positive feedback from her students. The effective use of technology in class has allowed them to develop a better understanding of the subject matter as compared to lectures where they were more focused on note-taking than participating.

Building 21st century skills through interactive technology

Of the current technologies used in the education sector, interactive technology has the most potential to instill 21st century skills in students. Tools like digital whiteboards, interactive projectors, and interactive displays are used to facilitate more engaging ways to collaborate, present, and actively exchange ideas in class.

Digital whiteboards are software that either come pre-installed in specialized hardware, such as interactive displays, or are accessed as cloud-based applications that allow users to do whiteboarding on their laptops or touchscreen devices. Interactive projectors and displays, on the other hand, are hardware devices that also provide whiteboarding capabilities through similar yet different ways. Of the three technologies, only interactive displays have the potential to combine all of the functionalities that we have discussed so far without the use of an external device such as a computer.

Interactive projectors vs interactive displays

A typical interactive projector setup has five parts: a projector, a touch camera mounted on the projector, a projection surface, a specialized stylus, and an external device with digital whiteboard software. Interactive projectors are often mounted onto ceilings or fixtures opposite the projection surface. Once set up, they can use any projection surface as a makeshift whiteboard.

An interactive display is a standalone hardware device with built-in touchscreen technology. It is akin to a large tablet that comes with its own operating system and applications, such as file managers and digital whiteboards. It is tactile-sensitive and responds to touchscreen pens. Most of them come ready-to-use and require very little instructions to operate.

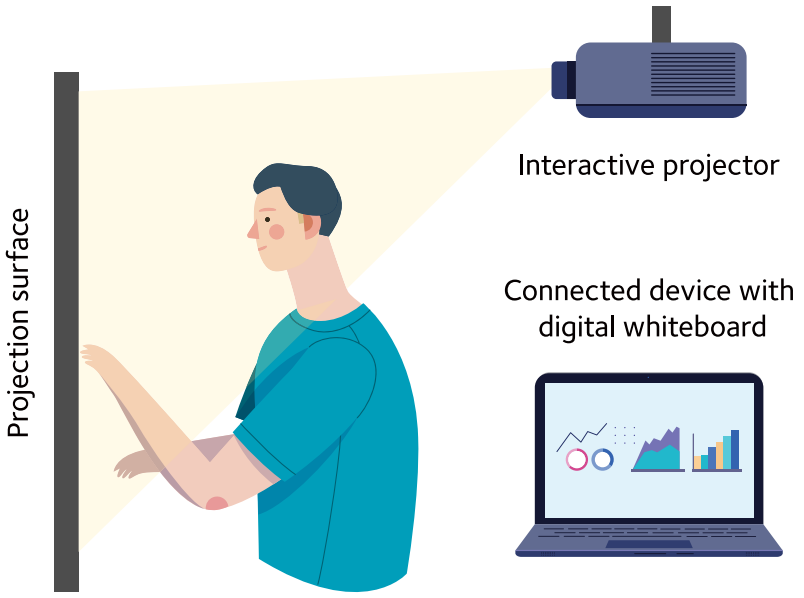

Figure 2. Typical interactive projector setup

There are three key advantages of an interactive display over an interactive projector, the main one being that it offers a better writing experience. Whereas most interactive displays offer high levels of responsiveness and accuracy, that is not always the case with interactive projectors. The infrared (IR) touch camera used on interactive projectors to detect the touch points requires a clear line of sight to the IR transmitter attached to the front of the stylus. If an object, such as a hand or sleeve, blocks the IR signal from reaching the touch camera, the projector may not be able to calculate where the touch points are. On the other hand, almost all interactive displays use capacitive touch and infrared sensors, which are behind and directly on the screens, respectively. As a result, the touch points are also more responsive and accurate.

The second important difference is the brightness of the displays. Most projectors are not bright enough to display clear images in well-lit rooms. This is not the case for interactive displays as they are capable of producing images that are suitable for most ambient lighting found in classrooms.

The third advantage is that interactive displays do not rely on hardware add-ons or input from external devices to function as a presentation screen or digital whiteboard. Typical interactive displays have built-in ports for data transfer and network connectivity, which allow users to easily load presentations from connected storage devices like USB sticks or download them from the internet.

Although it seems as if interactive displays outperform interactive projectors in many aspects, interactive projectors have two size advantages over its counterpart. For one, if an interactive display does not allow expansion through an additional screen or an expansive software interface, your workspace is limited to the screen's physical size. Such isn't the case for interactive projectors whose work area is adjustable depending on the strength of its throw. The other size advantage of interactive projectors is that its form factor is much smaller. If space is an important factor, a mounted projector would be a more logical option.

Table 4. Differences between interactive projectors and interactive displays*

	Interactive technology	
	Projectors	**Displays**
Work area	Projected on any flat surface	Screen
Workspace size	Dependent on projector throw	Dependent on screen size
Workspace size expansion	✓	✓
Network connectivity	✓	✓
Touch points	~4	~20
Touch response time	~16ms	~8ms
Presentation capability	Requires separate hardware with presentation software/media player	Built-in software
Whiteboarding capability	Requires installation of additional hardware/software	Built-in software

* Items may vary depending on projector and interactive display model specifications.

Around 31% of educational institutions around the world already have interactive displays installed in their classrooms. That figure will only increase as more and more schools replace and upgrade their projectors and interactive whiteboards.[13] Interactive displays are set to soon supersede interactive projectors due to the growing recognition of the latter's advantages.

Physical whiteboards vs interactive displays

Using whiteboards for discussions is a staple of classroom-based active learning. Students can huddle in front of a board to flesh out ideas through mind maps and diagrams, while teachers can highlight salient points for further discussion. An interactive display with a built-in digital whiteboard closely mimics this experience while increasing the possibilities for ideation.

Interactive displays allow users to load their own presentations (whether through a local storage device, cloud storage, or a virtual learning environment such as Blackboard, Moodle, or Canvas), annotate on them directly from the screen, and insert and move elements such as text or imported images onto the workspace. They can also open new windows on interactive displays without having to erase whiteboard content, so that they can switch between two or more workspaces with ease. Some digital whiteboards even come preloaded with features such as handwriting recognition, intuitive screen capture, and graph templates, making them more convenient to use.

Interactive displays free up the time needed to erase written notes and illustrations or transfer them to another medium. Teachers can simply export whiteboard sessions as documents or videos which they can then review post-class or send as notes to all students.

Traditional projectors vs interactive displays

In a setup with a traditional display or projector, if the teacher is not equipped with a presentation clicker, the teacher or presenter must always be near their computer in order to control the content displayed. Whenever they need to annotate input from students, they also need to do so on a separate area where the notes can be saved for later documentation. These limitations can prove inconvenient in an active learning environment that requires constant interaction and flexibility.

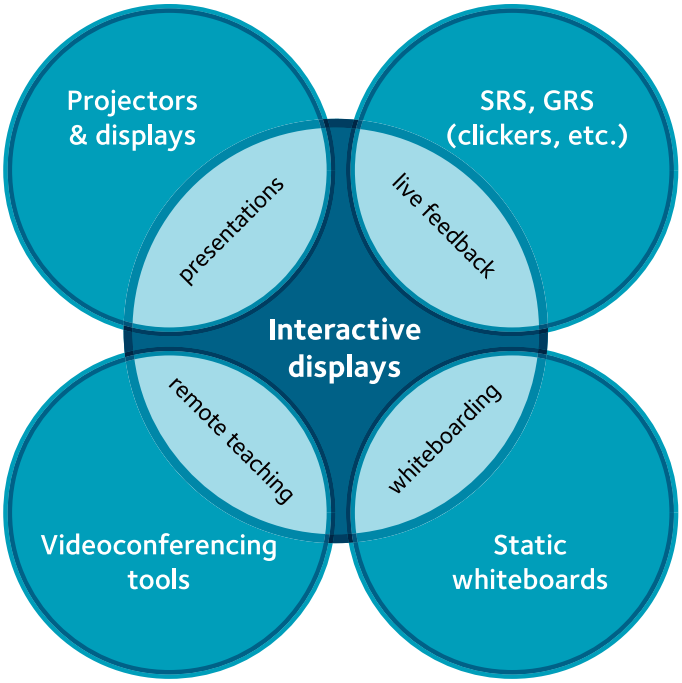

Figure 3. Common features shared by interactive displays with other classroom technologies

With interactive displays, instructors are freed from these physical constraints. They can easily adjust presentations in real-time, making the teaching session more organic and free-flowing. Some interactive displays also allow multi-device mirroring—a feature that lets students view the built-in digital whiteboard through their own personal devices. They can follow the sessions more closely, and, if their whiteboarding technology allows them, they can directly contribute content through their mobile phones, tablets, or laptops. This type of setup is advantageous for a number of reasons:

1. Anonymous responses encourage all types of students to participate.

2. Multiple students in large classroom sessions can contribute at the same time, allowing for real-time collaboration and more efficient collection of responses. This eliminates the need for external SRS or GRS.

3. Remote students can participate in the lecture, transforming what would have been a passive learning session into an active one. This also removes the need for additional voice conferencing hardware.

05 Application of active learning strategies

Instructors at the UCL Department of Science, Technology, Engineering and Public Policy (STEaPP) have developed an active learning strategy toolkit that aims to impart 21st century skills to their students. During lectures, instructors use interactive technology for exercises and other activities to increase student engagement and help them develop independent thinking and collaborative working skills. Interactive displays are not only used to conduct these activities, but they are also used to collect feedback from both students inside the classroom and those participating remotely.

UCL STEaPP instructors have observed an increase in the level of engagement from active learning in their sessions. They have found interactive displays easy to use especially for facilitating collaborative work involving large groups. When used in concert with software applications such as Formative, Kahoot! and Socrative, interactive displays create a fun environment where students remain engaged and motivated. The anonymity offered by these feedback technologies and exercises also

encourages participation from every single learner during the session. The technology helps to ensure that timely feedback can be exchanged between teachers and students so that any time during the lesson, if further elaboration or clarification is needed, issues can be addressed immediately.

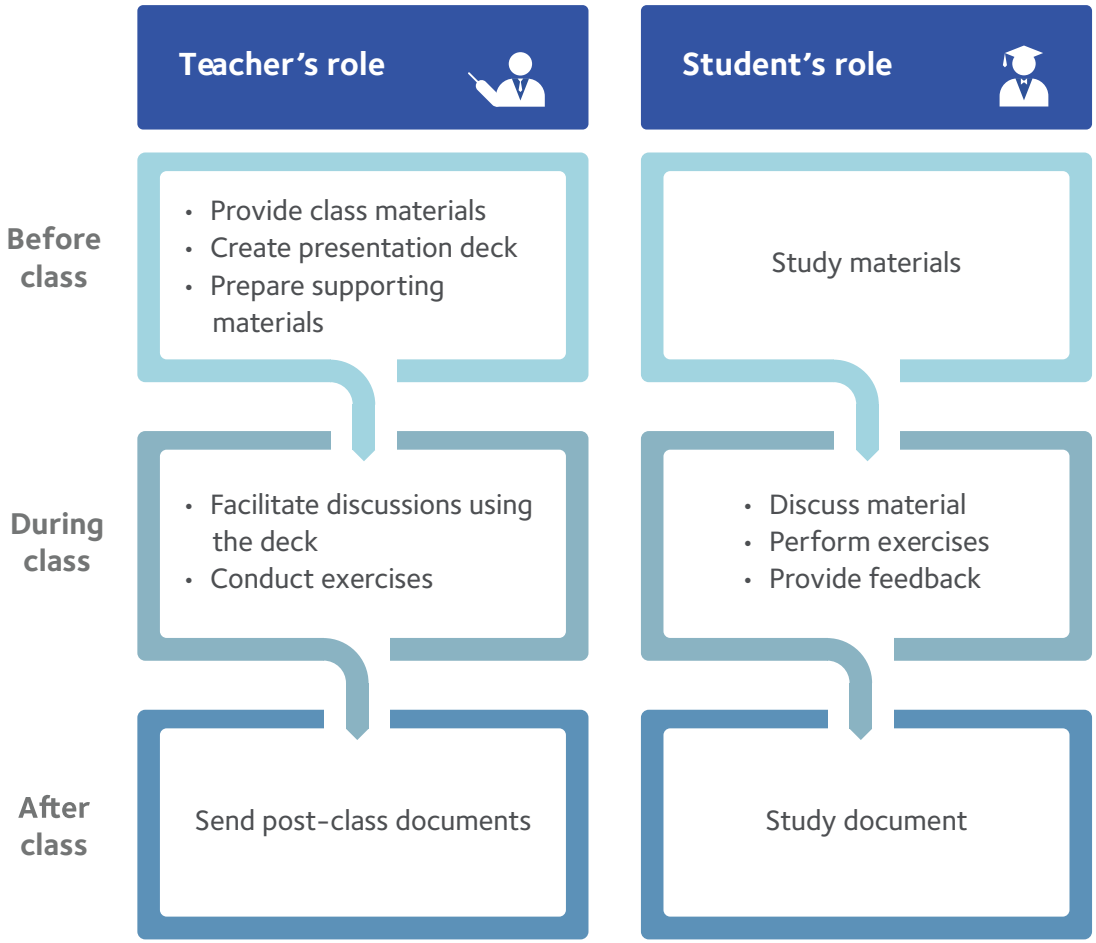

Figure 4. Sample workflow for an active learning session

Typical classroom sessions that use the active learning strategy toolkit are structured this way: First, instructors create their presentations with feedback collection in mind. When they customize the content and format of their presentations, they add portions where they can address questions to the class. During the lesson, instructors post these questions on the display and invite students to respond through digital sticky notes using their personal devices. Since the display has a built-in timer, students can see how much time they have left before the polling closes. During the waiting period, they can watch their responses accumulate in real time. If the responses require further addressing through other resources

such as a presentation slide or an external document, the instructor will retrieve and display them on the screen and use a pointer to draw attention to particular key points. They also annotate images, text, or diagrams to clarify concepts. After the class, the instructor downloads the responses and analyze them. These can then be shared with the students along with the screenshots of the notes that were written on the board during the lesson.

Admittedly, there is currently no one-size-fits-all answer on how to best develop skills for collaborative working, problem solving, and critical thinking. But there are several exercises an instructor can draw on to sharpen these skills. Below are a few options that can be deployed with the aid of an interactive display.

Entry and exit tickets

Entry and exit tickets are short prompts or guide questions that allow instructors to take a quick diagnostic assessment of their class.

An entry ticket may be used to focus students' attention on the day's topic or make them recall background knowledge relevant to the day's lesson. For example, the instructor can preface the discussion by asking their first impressions of the material.

An exit ticket, on the other hand, collects feedback on students' understanding of the content at the end of the class. This provides the students with an opportunity to reflect on what they learned, prompting them to process and integrate the information they gained during class. Instructors can also use this as a final opportunity to clarify points of confusion. They can pose a question like "Which part of the lesson did you find difficult to comprehend?"[14]

There are numerous pedagogical benefits to using entrance and exit tickets in class. These include ensuring participation from every student, prompting them to focus on key concepts and ideas, and supplying important feedback that can be used to influence teaching decisions, such as course-pacing, detecting and clarifying misunderstandings, and weighing student interest.

Think-pair-share

This type of activity requires students to consider a question on their own and then provides them an opportunity to discuss their ideas in pairs. The question is then opened to the entire class during a plenary, at which time the outcomes and key points that arose from the smaller discussions are shared.

The questions are meant to encourage deeper thinking and problem solving. The group discussions also induce critical analysis as they push students to articulate their thought processes. Its main benefits include the scope to engage every single student in the classroom.

Case studies and problem-based activities

Case studies are either hypothetical or actual scenarios that allow students to apply concepts learned in class to real-life situations. This activity forces students to critically approach each scenario, identify the root issues, and brainstorm potential solutions.

Scenarios are normally presented in narrative form and are released sequentially and in phases so that students gradually receive information as the case unfolds. This way, as the case evolves and increases in complexity, it compels students to remain flexible and critical. It trains them to think on their feet, quickly analyzing which details are important, and changing tack according to the most pressing needs.

Similar to case studies, instructors can also use problem-based activities to give students an opportunity to learn about concepts in more depth. Unlike case studies, these activities usually focus on quantitative problems. These types of activities are designed to enhance students' 21st century skillsets, sharpening their problem-solving, decision-making, and critical-thinking skills.

Interactive displays used for practical small group learning sessions

"Learning is more active which makes it easier to learn and understand."

—University of Derby MBA student

The University of Derby installed interactive displays in their bespoke learning space specially designed for small groups use. The setup offers their students experiential learning opportunities that mirror the workplace.

Students can take advantage of one of many pods, each equipped with a movable interactive display. This allows the space to be reconfigured as required so that all group participants can easily physically access and get a full view of the screen.

With highly intuitive multi-touch capability supporting up to five touch points, students control the on-screen content the same way as they would on a tablet device.

The interactive display also comes with free software that enables students to wirelessly cast the content on their device onto the interactive display in real time. This allows any participant in the group to share their screen and annotate with their peers in a seamless way.

06 | Case studies

In this chapter, we present three case studies that reflect different learning approaches where interactive technology is used by postgraduates as a mode of instruction and a medium to exchange information and practice 21st century skills. Some of the key practical and professional skills practiced include high-level critical analysis, communication and presentation, plus independent and collaborative working. The demand for these skills in completing postgraduate requirements is in-line with the expectations from global employers.

The first case study led by Dr. Alex Chung of UCL STEaPP shows a practical demonstration of active learning techniques using an interactive cybersecurity policy map. The second study covers Dr. Ine Steenmans', also from UCL STEaPP, use of narrative storyboarding to actively engage participants as they explore different research methodologies. The third illustrates three distinct peer-to-peer learning sessions conducted by Dr. Ying Yu of Oxford University, UCL STEaPP's Dr. Chung, and De Montfort University Lecturer Dr. Tian Ma.

All instructors use BenQ interactive displays to demonstrate the advantages of using technology in these case studies for master- and doctoral-level teaching and knowledge sharing.

Case 1: Policy mapping on interactive displays at UCL

Professor Madeline Carr, Director of UCL's Digital Technologies Policy Laboratory, invited Dr. Alex Chung to deliver a lecture for the STEaPP Master of Public Administration (MPA) Digital Technology and Public Policy route. The goal of this session was to provide an opportunity for the students to examine real-world digital and cyber policy scenarios.

For this session, Dr. Chung required a digital solution that both he and his students could use to create and analyze a policy ecosystem map. Professionals often use these mind maps to examine wicked problems that exist in a country. Wicked problems are complex, open-ended, intractable, and hard-to-manage policy issues made more difficult to understand, define, and solve because of their interdependencies with other public policy domains. Mind mapping helps researchers visualize how multiple policy-related elements are connected and allows them to better manage wicked problems.

Previously, Dr. Chung used conventional displays and projectors to present maps. He found the experience time-consuming and less immersive. Since his presentations required him to operate maps using a mouse or trackpad, he constantly needed to switch his focus from the laptop screen to the display. This old setup also greatly hampered student participation since it was not possible for them to add their input on the maps during the discussion.

Figure 5. Dr. Alex Chung explains how the interactive policy map was developed.

Hands-on approach to wicked problems

Dr. Chung presented the interactive UK cybersecurity governance and policy map on a BenQ interactive display. The map, which he and Professor Carr had developed, illustrated the true complexity of the UK's cybersecurity landscape and showed which government sectors were responsible for creating cybersecurity policies. The students were first briefed on the map and the methodology used to create it so that they could replicate the visualization technique when producing similar policy ecosystem maps for their own selected countries.

The interactivity afforded by the display made it the perfect medium for analyzing wicked problems. The students got a full hands-on experience. "Hands-on" here is used in the literal sense—they were able to physically navigate and alter the digital map during the session.

Figure 6. A participant moves on-screen elements using the BenQ interactive display's touchscreen feature.

Dr. Chung found the experience very intuitive. Through simple hand gestures—swiping, pinching and pulling, tapping and holding—he was able to interact with data points on the map, moving up and down organizational levels and across policy areas. It allowed him to better emphasize key points compared to when he previously presented the map behind a laptop.

The interactive display's user-friendliness also allowed the students to start navigating the map without the need for additional instructions. It encouraged them to get up from their seats and gather around the screens to discuss ideas. One by one, they took charge of navigating the map alongside their peers.

The students' perception of their own approach to learning changed as soon as they started using the interactive display. They played a more active part in the process and engaged with their peers more.

Figure 7. Participants become more active in group discussions while analyzing the interactive map.

As their attention increased with the interactive display, students were more intent on listening to ongoing conversations and observing their peers' expressions and body language while decreasing their use of personal devices. Throughout the exercise, students demonstrated enhanced communication, critical thinking, collaborative working, and creativity.

The experience also made the session enjoyable. From the students' initial feedback, they found the kinesthetic learning experience (using their hands to explore ideas) both productive and engaging. It not only improved their understanding of the subject matter but made learning fun.

Case 2: Enhanced interactive doctoral training at UCL

As part of the UCL STEaPP's doctoral training program, professors hold formal workshop-style sessions that aim to develop skills that graduates can apply to future research and employment.

During the first term of 2019, Dr. Ine Steenmans held two two-hour sessions that aimed to deepen doctoral students' understanding of concepts using design tools and case studies for research. She wanted to adopt a learner-centered strategy, which enabled students to co-design narratives by collectively synthesizing and critically evaluating different research methods.

This active learning approach is based on the idea of a storyboard. She first introduces a narrative that students can continue building through discussions which dictate the pace and path of learning. Since the sessions are driven by the narrative, it is essential for students to keep track of how it is being shaped and how far along they are in the problem-solving process.

When Dr. Steenmans ran these sessions in the past, she had to use separate equipment: a traditional whiteboard and a computer connected to a projector or screen, which allowed her to display slides. This setup was limiting in a number of ways. First, the content was not easily transferrable, meaning text and diagrams on whiteboards could not be instantly ported to the presentation and vice versa. Second came the space constraints. When the whiteboard ran out of space, whatever was written needed to be captured via a digital camera and then erased before the session could proceed. Not only was this time-consuming, students also found it difficult to keep track of the discussion when they could no longer visually follow the previous parts of the narrative chain.

Testing research methods through narrative storyboarding

Dr. Steenmans used the BenQ interactive display for its built-in collaborative features that suit fluid teaching styles. The interactive display allowed her and her students to stay focused on the ongoing narrative, gradually building it throughout the session using annotations and imported media.

Figure 8. Dr. Steenmans uses EZWrite on the BenQ interactive display to visualize the ongoing narrative.

In both sessions, Dr. Steenmans introduced the beginning of the narrative using a prepared slide presentation, which she quickly loaded on the display. From there, she opened the discussion, gathering student feedback and plotting the progress using the EZWrite, BenQ's whiteboarding software. Not limited by medium or space constraints, discussions were able to flow freely.

Another benefit of using the interactive display was how it let students participate freely without the distraction of notetaking. Dr. Steenmans could just take snapshots of the screen and then share the images files with students at the end of the session.

"The interface is very intuitive. It required no formal training on my part," said Dr. Steenmans.

According to her, the sessions became more seamless. She could easily transfer content from her presentation slides to EZWrite where she and her students could add ideas or build on existing ones. "The display is very accurate in capturing input. It reduces the time it takes to add student contributions," she said. EZWrite also allowed continuous writing on multiple pages so nothing needed to be erased; she and her students could easily just navigate the whiteboard to backtrack.

"I like how the interactive display incorporates technology into teaching in a subtle, non-disruptive manner," said Dr. Steenmans. "This subtleness is important because it allows me and my students to better focus on the topic at hand."

Case 3: Active peer-to-peer learning at Oxford University

Oxford scholar Dr. Ying Yu and UCL's Dr. Alex Chung convened and hosted a group discussion on topics in criminology and criminal justice at Oxford University's Wolfson College. The event brought together several researchers who specialized in a range of social science disciplines and studies in law, security, criminology, and justice. These included Dr. Tian Ma, a Criminology Lecturer from De Montfort University Leicester, and several PhD and Master's research students from UCL, Oxford, and other UK universities.

The session was aimed at facilitating knowledge sharing among researchers so that they could gain a better understanding of their respective areas. One of the objectives was to exchange ideas about useful research methodologies in order for participants to apply the shared learnings appropriately to their own research agendas. As some of the participating students were contemplating future career paths, the gathering also served to broaden their perspectives horizontally across interdisciplinary studies and identify potential opportunities.

Organized crime research and transnational criminal networks

Dr. Chung introduced his research on organized crime centered on the activities of an Asian transnational criminal network during a certain time period. Using a BenQ interactive display, he illustrated who the criminal players were, how the illicit networks were structured, and the types of criminal businesses in which these people were involved. As his research used network diagrams (also known as sociograms) to depict criminal associations that formed during illicit transnational activities, the display was particularly convenient in bringing the evolution of the criminal networks to life.

Using the interactive display's touchscreen capability, the students participated in hands-on exercises where they manipulated the sociograms shown on the device. Dr. Chung demonstrated how they could move nodes, which represented criminal actors, in sociograms to form different network configurations. For example, he explained that in order to accentuate the value of a broker—an individual who acts as the bridge

between others and controls information flow—within the network, they could isolate the node clusters bridged by the broker. Doing this revealed the value of that particular brokerage position.

This interactive element of the discussion was crucial in helping participants really understand how this methodology can be employed in practice. It showed how one could optimize the representation of criminal networks in order to test different research hypotheses, such as whether a criminal actor has high or low brokerage value. It would have been challenging to demonstrate this using static illustrations on a conventional screen or projector.

Figure 9. Dr. Chung demonstrates the evolution of criminal networks on the interactive display.

In addition to getting the participants to visually appraise criminal networks, they were also able to more readily grasp the data collection process and methodology behind how the diagrams were constructed. For Dr. Chung's sociograms, different types of data on the criminal players' associations with one another and their personal attributes were extracted from firsthand materials such as court documents and trial proceedings' transcripts as well as police criminal investigation files. The data was then used to populate a matrix table and fed into a social network analysis software program, which generated the sociograms and metrics to highlight the network properties of the actors and clusters.

In this session, the interactive display helped portray how criminal networks operated; connections became more concrete and less abstract. More importantly, the interactive display allowed other researchers to fully participate in the discussions through hands-on learning.

Criminology and criminal justice studies

Dr. Ma gave an overview of her research projects in the fields of criminology, criminal justice, and migration studies. On the interactive display, she illustrated several related concepts from different lines of inquiries and schools of thought in these disciplines. These included the linkages between the criminal justice system and legal studies, co-offending theories, domestic violence research, victimology and reconciliation, and rehabilitation practices.

One of the participants was keen to explore the prospect of undertaking prison research as an extension of her current postgraduate study in forensic psychology. Dr. Ma took this opportunity to brainstorm with her to look for potential avenues for conducting topical research in prison studies. This discussion revolved around criminal justice organizations that were salient to this research area, such as the National Offender Management Service.

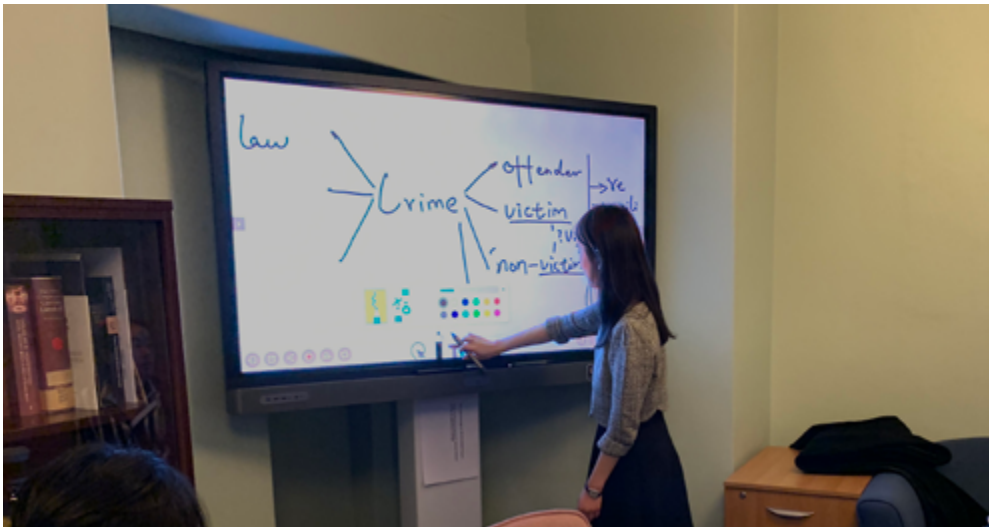

Figure 10. Dr. Ma brainstorms criminology and criminal justice research topics with participants.

During the discussions, Dr. Ma invited the participants to share and collide their thoughts about related research gaps as well as questions that came to mind while whiteboarding. They used EZWrite's coloring scheme to mark individual input. Intersecting ideas were highlighted, revealing new distinct research themes. At various junctures, Dr. Ma took screenshots to capture the brainstorming process and emailed them to the participants to track the development of their ideas for future reference and processing.

A few researchers who could not attend the meeting, as they were based elsewhere in the UK, were able to dial into and contribute to this session remotely via Skype Business. Using the EZWrite, which allows remote whiteboarding, Dr. Ma asked offsite peers to pitch in thoughts about relevant charity organizations that they deemed part of the complex criminal justice landscape. These peers then added a number of important organizations and the rehabilitation provisions being offered to those serving time in prison by drawing them onto the tree diagram directly from their own digital devices.

Perspectives on law, security, and justice

Going back to research methodology, Dr. Yu discussed her experience doing legal and socio-legal research on dispute resolution in a legitimate commercial setting. Drawing on the concept of information sharing and reputation as mechanisms for increasing one's trustworthiness during trading, she noted that the underground trafficking of illicit commodities shares many similar traits with regular commercial transactions.

Figure 11. Dr. Yu (far left) discusses the application of legal concepts to crime research.

Dr. Yu then asked both the onsite and offsite peers to share their practical experiences and methodologies for conducting research and apply those to areas such as security, crime, and law enforcement. As one of the most commonly encountered difficulties facing criminology scholars, it was important to consider the various ways by which one could acquire useful sources of information at the outset of undertaking fieldwork. The goal in this case would be to successfully gather firsthand data through conducting interviews and collecting documents while minimizing risks and without compromising the researcher's safety.

They exchanged views on the practical challenges of obtaining data on policing and the criminal justice systems of different countries. To facilitate the discussion, the participants again shared a digital whiteboard through EZWrite and drew up separate columns that represented the characteristics of the different systems that are currently being implemented in Western and Asian countries. By comparing and contrasting these characteristics, the researchers were able to identify existing knowledge gaps that could warrant future research.

Figure 12. A PhD student discusses fieldwork and methodology in policy research.

Another set of challenges that was discussed concerned how one could leverage digital tools to investigate and visualize the geography of crime in addition to network analysis techniques. To this end, the participants used the interactive display to explore a number of online tools available in the public domain that could be used to map out crime using dynamic or three-dimensional models. This part of the discussion stimulated ideas

about the potential for developing bespoke geographical crime mapping software that could better address the needs of academics working on integrating the temporal and spatial properties.

Summary

Peer-to-peer learning is a key and essential aspect of the postgraduate student experience. The wide-ranging knowledge gained through a peer support network from a diverse base of experiences often takes the form of informal mentoring and guidance. As these are relatively frequent and flexible in format, depending on the needs of the particular student or cohort of students, this learning method is regarded by educators to be just as important as formal learning that takes place in classes or during one-to-one supervisor sessions.

These case studies illustrated the benefits and suitability of using interactive displays in a peer-to-peer blended learning environment. Using hands-on exercises employed through an active learning approach, the group of researchers and students, as shown above, were able to communicate their work to one another effectively and illustrate their findings interactively. These discussions involved using the interactive display to brainstorm ideas, share domain knowledge and insights, discover research methodologies, and explore prospects for new paths and opportunities. Perhaps most importantly, this experience helped the researchers encourage and inspire one another in their work and as a result, further solidified the existing social bonds in their peer support network.

Do your graduates measure up?

To address the growing 21st century skills gap, educational institutions must take stock of their learning spaces and curricula and gauge whether or not these are adequate to their students' needs. For schools looking to convert their classrooms to active learning environments, here are some points for consideration:

Why switch from traditional teaching tools to interactive technology?

Interactive technologies allow educators to explore and apply new and different teaching methodologies that would otherwise be difficult using traditional tools. These methodologies allow students to better exercise the skills and competencies they will need in the workforce.

Won't introducing more technology into the classroom add more distractions?

Using interactive technology as a medium of instruction actually refocuses a student's attention. Rather than getting distracted by their own personal devices such as laptops, tablets, and smartphones, they will be more inclined to participate in classes that require them to be more hands on with their learning. Since interactive technologies may allow the exporting of lectures, they can also free students from notetaking, giving them more room to focus on discussions.

Will interactive technologies work with our current system?

Different interactive technologies have specifications that may or may not be compatible with different systems. BenQ interactive displays are integrated with Microsoft® Office and Google G Suite™ and work with most notebooks, computers, and other personal devices

Deploying interactive technology in digital classrooms

1. Assess which technologies would benefit your classrooms the most.
2. Check their specifications and determine if they fit the criteria you set in terms of use, quantity, and performance.
3. Work out a realistic deployment schedule that is most convenient for your organization.
4. Train your staff on the benefits and proper usage of interactive technology.

Experience the BenQ advantage

Discover how BenQ can help transform your classrooms into digital learning spaces that facilitate student learning efficacy, engagement, critical thinking, and problem solving.

Education technologies

Our products are designed with education in mind. From traditional projectors and monitors to interactive technologies, we offer solutions that cater to every need.

Education experts

Our experienced staff will work with your school to identify gaps and determine the best way to achieve your academe's goals.

High performance, low maintenance

Our smart interactive devices can be monitored and managed remotely by IT staff to lower the overhead of maintaining your new interactive learning spaces.

Ready when you need us

Whether it's for consultation, technical support, or even staff training, our local offices are ready to help in any way.

References

1. Schwab, K., The Fourth Industrial Revolution, World Economic Forum, 2016, p. 11-13.
2. Schwab, K and Samans, R., 'Skills Stability', The Future of Jobs Report, World Economic Forum, 2016, last accessed December 2019.
3. Schwab, The Fourth Industrial Revolution, p. 37.
4. Ibid., p. 14.
5. Schwab, Samans, The Future of Jobs Report.
6. Assessment and Teaching of 21st Century Skills, last accessed December 2019.
7. Friesen, N., Defining Blended Learning, 2012.
8. Ellis, R. and Goodyear, P., Students' Experiences of E-Learning in Higher Education: The Ecology of Sustainable Innovation, Routledge, 2010.
9. Laurillard, D., Teaching as a Design Science: Building Pedagogical Patterns for Learning and Technology, Routledge, 2012.
10. Sutherland, P., Badger, R., and Goodith, W., 'How new students take notes at lectures', Journal of Further and Higher Education, vol. 26, no. 4., 2002, p. 377–388.
11. Cutts, Q. et al., Maximising Dialogue in Lectures Using Group Response Systems, 2004.
12. Bailey, E., Six ways to get students to really learn during a lecture, 2019, last accessed December 2019.
13. Messenger, C., Futuresource Report: World Interactive Displays, November 2019, p. 7.
14. 'Entry and Exit Tickets', The Harriet W. Sheridan Center for Teaching and Learning Resources, Brown University, last accessed December 2019.