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eLearning technology and the advancement of practical constructivist pedagogies: Illustrations from classroom observations

Paul L.C. LAM[1] · Hilary K.Y. NG[1] · Alan H.H. TSE[1] · Ming Lu[2] · Bernardo Y. W. WONG[1]

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Abstract

With the advancement of technology, eLearning is increasingly adopted as an instructional method in a wide range of educational settings and has opened up new possibilities in teaching and learning practices. However, there is insufficient empirical evidence to illustrate how eLearning benefits teaching and learning practice in its real-world applications. Therefore, an important question is raised – How can eLearning technology facilitate pedagogical advancement practically in the classroom? In this study, we focus on constructivist pedagogies, emphasizing the dramatic educational reform from teacher-centered pedagogy to a student-centered, constructivist approach. Based on observations of 79 eLearning classes in eight primary schools, four secondary schools, and two special education schools in Hong Kong, this study illustrates how eLearning technology can advance at least five constructivist pedagogies: 1) active learning, 2) student-centered learning, 3) peer learning, 4) personalized learning, and 5) differentiated learning. We illustrate that the interactive, self-paced, repetitious, and customizable features of eLearning systems facilitate the implementation of these five constructivist pedagogies. Successful examples from classroom observations are drawn to illustrate how teachers make practical use of eLearning technology. This article serves to stimulate further discussion on how eLearning can be applied across various settings to advance the effectiveness of constructivist pedagogies and to encourage practitioners to consider how to make use of eLearning technology in the classroom.

Keywords eLearning · Pedagogy · Learning technology · Observational study · Constructivism

✉ Hilary K.Y. NG
hilaryng@cuhk.edu.hk

Extended author information available on the last page of the article

1 Introduction

The rapid progression of eLearning technology is shaping teaching and learning practices (Lucas and Kinsman 2016). While there are different definitions for eLearning, it is generally agreed that eLearning is a process in which teaching and learning is facilitated by computers and other associated technologies (Littlejohn and Pegler 2007; Philips, McNaught, and Kennedy 2012). Much research attention on eLearning has been devoted to learning outcomes, for example, heightened learning satisfaction and performance (Eom 2014), enhanced higher-order thinking skills (Hedberg 2006), and learning motivation (Groff 2013; Huffaker and Calvert 2003). Apart from improving learning outcomes, eLearning technologies have also been shown to enrich the entire learning process with four important features (Twigg 2002; Huffaker and Calvert 2003). First, eLearning systems are generally designed to include interactive media, which can encourage participation in learning activities and motivation. The interactive features of Web 2.0 can also facilitate communication and enhance learning by enabling teachers and students to give and receive instant feedback to each other. Second, eLearning systems are self-paced, allowing students to set learning goals independently and progress in their learning pathways at their own pace. Third, the learning contents of eLearning materials can be accessed repeatedly such that students can revisit difficult concepts for clarification. Finally, the learning contents in the eLearning system can be customized by teachers to attend to individualized learning needs. These four features can provide a more interactive, individualized, and student-centered learning environment when compared to a traditional classroom. Thus, eLearning technologies, when incorporated into the traditional classroom, have the potential to transform the learning environment. However, empirical research on how eLearning can open up new opportunities to advance teaching and learning practices remains insufficient. This research, therefore, aims to illustrate how eLearning can be applied to enrich the learning process in the face-to-face classroom setting.

eLearning holds promising power to enrich the learning process, which in turn provides valuable opportunities to bring different philosophical pedagogies into real practice. The present research focuses on constructive pedagogies, even though the potential of eLearning extends beyond this scope. We choose to focus on constructive pedagogies in light of the dramatic educational reform from teacher-centered pedagogy to a student-centered, constructivist approach (Tobias and Duffy 2009; Yang et al. 2008). This pedagogy has been the major theoretical foundation for education nowadays as it not only focuses on addressing students' individual differences during their learning process but also provides opportunities for students to establish the linkages between the new concept with the pre-existing knowledge, ideas, and beliefs (e.g., Richardson 2003; Staver 1998; Windschitl 2002; Yang et al. 2008). Therefore, the major objective of this research is to understand how eLearning can be adopted to practically implement constructivist pedagogies. Specifically, the following five constructivist pedagogies will be investigated: 1) active learning, which emphasizes students' own exploration through engaging students in different learning activities (Bonwell and Eison 1991; Prince 2004), 2) student-centered learning, which encourages students to make their own choice in their learning pathways (Rogers 1983), 3) peer learning, which provides opportunities for students to learn together through cooperation and competition (Topping 2005), 4) personalized learning, which focuses

on fulfilling the unique learning needs of different students (Lu 2004), and 5) differentiated learning, in which teachers tailor specific instructions to suit students' unique learning needs (Tomlinson 2003). Hence, this research investigates these five different pedagogies to understand how eLearning promotes different aspects of constructivism.

2 eLearning applications for constructivist pedagogies

This study adopted a grounded theory approach to illustrate how eLearning technology can be practically implemented. The grounded theory approach enables researchers to investigate real-life phenomenon without any preconceptions (Babbie 2014). This study was part of a three-year longitudinal project that commissioned by the Education Bureau of Hong Kong (EDB) to evaluate the effectiveness of eLearning in the 12 years compulsory education system in Hong Kong. The 12 years compulsory education covers primary school (from primary 1, age 6, to primary 6, age 11) and secondary school (from secondary 1, age 12, to secondary 6, age 17). There were eight primary schools, four secondary schools, and two special education schools to participate in this study (see Table 1). All these schools participated in the Hong Kong Education Bureau's support scheme for e-Learning in schools (also known as "WiFi 100") from 2014 to 2016. This scheme was targeted to improve the WiFi infrastructure and to provide sufficient mobile computing devices for eLearning. These schools were pioneered to adopt eLearning in Hong Kong. In sum, we observed 79 classes that adopt eLearning technological tools to cover a variety of subjects, including English, mathematics, Chinese, general studies/liberal studies, and others. All 79 face-to-face classes were observed by at least two research team members, and all classes were videotaped and evaluated. During observations, researchers completed the Classroom Observation Protocol for Undergraduate STEM (Smith et al. 2013; COPUS) independently and discussed the discrepancies afterwards. This protocol characterized how teachers and students spend time in the classroom. Hence, the in-class observations were served to identify how eLearning can be implemented during the entire learning process, rather than to evaluate the learning outcomes.

In the section below, we first briefly describe the features and benefits of each of these five constructivist pedagogies, including, 1) active learning, 2) student-centered learning, 3) peer learning, 4) personalized learning, and 5) differentiated learning. Then, we illustrate the pedagogies with examples from classroom observations. Our aim is to understand how eLearning technological tools can be implemented to promote constructivist teaching and learning practices, and hence only the representative examples are shown. A summary of the philosophical pedagogies discussed in this paper is provided in Table 2.

Table 1 *Descriptive Statistics for In-class Observations*

	Number of participating schools	Number of eLearning classes observed
1. Primary Schools	8	37
2. Secondary Schools	4	29
3. Special Education schools	2	13

Table 2 *Summary of Philosophical Pedagogies*

Pedagogies	Cases	Levels	Subjects
Active Learning	Case A	Primary 6	English
	Case B	Secondary 4	Liberal Studies
Student-Centered Learning	Case C	Primary 6	Mathematics
Peer Learning	Case D	Primary 6	General Studies
	Case E	Secondary 2	Integrated Science
Personalized Learning	Case F	Primary 3	English
Differentiated Learning	Case G	Special School (Junior Secondary)	Mathematics
	Case H	Special School (Key Stages 3)	Chinese

2.1 Active learning

Active learning transforms the traditional relationship between teachers and students by reducing the emphasis on one-way knowledge transmission from teachers to students. In an active learning classroom, students no longer sit passively as an audience listening to a presentation. Instead, they participate in activities that develop higher-order thinking skills (Bonwell and Eison 1991). Common active learning strategies include reflection, writing, group discussion, peer review, and role-playing (Meyers and Jones 1993). These learning activities are structured in ways that facilitate the understanding of concepts and principles (Puntambekar and Kolodner 2005). Hence, the focus of active learning is on how to engage students in the learning process. Empirical findings suggested that active learning pedagogy has a positive effect on student motivation, engagement, performance, and creativity compared to traditional lecturing (e.g., Freeman et al. 2014). A recent meta-analysis also showed that learning in a technology-enabled active learning environment is more beneficial to traditional lecture-based environment (Shi et al. 2020). Beyond this, active learning approach has also been useful and effective to offer an inclusive learning environment for students from diverse backgrounds, such as reducing the achievement gap between disadvantaged and non-disadvantaged students (Haak et al. 2011), or improving performance and motivations among female students with learning disabilities (Qadan 2016).

Our observations in these 14 schools show how eLearning technology can facilitate active learning in the classroom. One common practice was to spend more class time on interactive learning activities through technological tools, which provided opportunities for students' active involvement and self-exploration of the learning content (Bonwell and Eison 1991). For example, in a Primary 6 English reading comprehension class, students were asked to read a paragraph about Hong Kong festivals on their iPads and then complete several related multiple-choice questions using a student response system on Nearpod after a group discussion (Case A). Students' responses were then shared instantly with the whole class through a classroom projector and Nearpod. The teacher discussed the responses one by one. Next, the teacher invited the students to share their favorite festival on iPads and explain their reasons. Students expressed their views by speaking up in

class or typing on their iPads. Students actively participated in this activity because each of them was allowed to express their opinion through their mobile devices. The teacher then summarized all responses and ended the class.

Similarly, in a Secondary 4 liberal studies class, the teacher made use of eLearning technology to arrange a series of in-class activities to teach self-concept theory (Case B). Students were first asked to rate their personal characteristics on a 10-point scale and explain their ratings. All the students' responses were sent anonymously to the teacher through their Nearpods, in which students could borrow the device from teachers if they did not have their own device. Then, the teacher introduced the theories of self-concept and applied these theories to analyze the students' responses. Because of the personal relevancy, this activity stimulated students' interest to master the basic understanding of self-concept. To help students engage in higher-order thinking, students were finally asked to apply the self-concept theories to analyze a video featuring a young adult with serious social difficulties and submit their responses via Nearpods.

In technology-enriched classroom environments, such as these examples, active learning is facilitated by the adoption of eLearning technology. In our observations, the students' tablets, the teachers' devices, and the classroom projectors were the necessary eLearning infrastructures to allow instant student response in class. Such active participation from students would not be possible in a traditional classroom setting where only one student could express his/her idea at a particular moment. Our observations also show how eLearning technology could give teachers a greater flexibility to design a more interactive learning environment and to make the learning process more engaging.

2.2 Student-centered learning

While active learning emphasizes students' active participation in the learning activities, student-centered learning further aims at encouraging students to become autonomous and independent students (Rogers 1983). Students' choice in their education pathways is the key element (O'Neill and McMahon 2005). They are not only given options to choose what to study, but also how and why the topic might be of interest to them (Burnard 1999). To achieve this, the relationship between students and teachers needs to be equal and respectful. Both parties ought to share a mutual aim to promote students' development (Lea et al. 2003). Specifically, students should take full responsibility for their own learning progress and must be actively involved in the learning process, while teachers should act as facilitators who can help students achieve their learning goals (Lea et al. 2003). In short, student-centered learning enables students to be fully responsible in their learning process to choose what they want to learn and how to learn. This skillset is essential for lifelong learning that enables them to ask appropriate questions and to reveal the related answers for different phenomenon without the assistant of a trainer (Wulf 2019). eLearning technology holds promise to transform the role of students and teachers, bringing student-centered learning into practice (Groff 2013).

An example from a Primary 6 mathematics class clearly demonstrates how eLearning technology can facilitate student-centered learning (Case C). During the lesson, students set their own learning objectives by choosing one of the figures (e.g.,

spheres, cones, and cylinders) in their textbooks. Then, they took photos with a mobile app in iPads to digitalize the chosen figures. With the digital illustrations on their mobile devices, students were encouraged to discuss and explore the properties of different three-dimensional shapes on their own, as well as to ask any questions when they needed. In the second half of the class, the teacher guided students towards a deeper understanding by introducing some other complicated methods to explore the properties of different shaped figures. In this example, students made decisions during their learning process, while the teacher acted as a facilitator to enhance the learning outcomes. The mobile device equipped with specific software enabled students to experiment on their own. Without eLearning technology, such student-centered experimentation would be less accessible. Thus, this example demonstrates how eLearning technology shifted the focus from teacher to student, the primary requirement for student-centered learning.

2.3 Peer learning

In addition to learning from their teachers, students can also learn from their peers. Peer learning refers to the educational practice where students attain their learning goals through interacting with companions of equal social status (Topping et al. 2017). It has been regarded as the most cost-effective learning strategy (e.g., Levin et al. 1987). Peer learning is shown to foster positive learning outcomes, such as critical reflection, reassessment of one's own point of view, and in-depth understanding of the materials (Boud et al. 1999; Boud 2001; Topping 2005). It has also been associated with increased psychological well-being (Hanson et al. 2016) as well as enhanced social skills, including collaboration and communication skills (Boud 2001; Topping 2005; Topping et al. 2017).

Peer learning can take place in different forms, but peer tutoring and co-operative learning have attracted the most intensive research (Topping 2005). Co-operative learning and peer tutoring refer to different social interaction patterns among peers. The former focuses on learning through developing a positive interdependence (Slavin 1990), while the latter highlights the structured learning process between tutor and tutee (Topping 2005). Specifically, co-operative learning emphasizes the development of a collaborative relationship to achieve specified learning goals and complete learning tasks with equal participation (Topping 2005). Peer tutoring focuses on structured materials and interactive behaviors.

Our school visits observed various examples of co-operative learning facilitated by eLearning technology. For example, in a Primary 6 general studies class, students were paired up to deliver a presentation on invertebrates (Case D). To prepare for the presentation, they were required to work co-operatively to search for information, identify graphics, and analyze features relevant to the topic with the use of Schoology. They could also access the online learning system to retrieve the course resources. Five groups were chosen at random to give in-class presentations. They prepared the presentation slides that composed of pictures, texts and analysis using Showme. Each group of students demonstrated excellent co-operative skills with a clear division of work during the presentation. Specifically, while one team member (student A) delivered the presentation, another member (student B) controlled the iPad with an access to

Apple TV and managed the presentation slides in line with the flow of his/her partner. If in-depth details were discussed, student B magnified the picture to assist the explanation of student A. Hence, the students created a good synergy with their learning partners and formed collaborative relationships in pursuit of the shared learning goals. As a result, students seemed to learn more than the subject content alone.

Apart from learning through co-operation, students can also learn through competition. The following example illustrates how technology can facilitate these two forms of peer learning (Case E). In a Secondary 2 integrated science class, students worked in groups of three to develop an electric circuit based on the diagrams provided by the teacher. When they formed a complete circuit successfully, the connected light bulb glowed. Then, they were asked to upload photos of their final products to the internet with the use of Nearpod. The first group that completed the task would be the winner. The teacher reported the groups' progress from time to time. Students were motivated to learn the foundation of electric circuits in order to win the competition. Hence, eLearning facilitated both peer collaboration within groups and competition between groups.

On the whole, our observations show that eLearning technology can be a valuable tool to assist peer learning. Technology-assisted classroom peer learning can facilitate both collaborative or competitive group work throughout the entire learning process because of its special ability to provide collaborative working spaces and mechanisms that encourage well-organized co-operative learning.

2.4 Personalized learning

A transformation of the relationships between students and their teachers alone is not enough to optimize the learning process and learning performance. The unique learning needs of individual students should be taken into consideration. Even in the same learning stage, each student comes with a unique knowledge background, a specific learning style, special learning demands, and different learning needs (Lu 2004). These factors play a substantial influence on the learning process and outcomes. For example, excessively difficult course materials or irrelevant materials can frustrate students, while excessively easy course materials can reduce students' sense of challenge and diminish learning outcomes (Csikszentmihalyi et al. 1993). A more personalized learning strategy can be achieved in a technology-enriched environment that is highly sensitive to the individual differences of students. A technology-enriched environment can build on what students already know and use this sensitivity and knowledge to provide tailored feedback for students, such as setting appropriate learning goals (DeMink-Carthew and Olofson 2020) and providing personalized feedback (Pérez-Segura et al. 2020).

In our observations, a series of activities were organized to teach the English vocabulary for dates, numbers, and time to a class of Primary 3 students (Case F). The teacher first introduced the basic expressions of time in English using videos, and then provided each student with a Samsung tablet, earphones, and microphone. Students then completed an interactive game that facilitated by the provided mobile devices. They could stop, pause, and play the game according to their preferences. During the game, students were first asked to select flash cards on their mobile devices

based on what they had heard through their earphones, and then students were asked to match the card with the correct Chinese translation before their answers were sent to the teacher through the internet.

This eLearning activity was able to meet individual learning needs in several ways. First, the teacher reviewed each answer and provided individualized feedback through the internet. Second, students learned according to their own learning progress because questions were repeated until they provided the correct answer. Third, students learned at their own pace because they were interacting with the eLearning tools independently. Thus, this example shows how the use of technological tools in eLearning can facilitate personalized learning. These tools can help teachers to identify the unique learning needs, knowledge background, and styles of individual students, and then create a learning environment that is responsive to each student's needs.

2.5 Differentiated learning

While personalized learning emphasizes the role of students in fulfilling their learning needs, another way to address students' unique learning needs is through differentiated learning. Differentiated learning, or differentiated instruction, is a teaching philosophy that emphasizes the matching of teaching practices to students' readiness levels, interest, and preferred modes of learning (Tomlinson 2003). In other words, the person who takes the responsibility in matching the learning needs of students is different in personalized learning and differentiated learning. The former is the students while the latter is the teachers. Differentiated learning allows teachers to provide instructional strategies that are appropriate to students' learning styles and needs, thus increase students' engagement and outcomes. Previous research demonstrated that differentiated learning that allows students in the same class to work on different tasks or homework according to their own levels of ability can improve students' learning outcomes (e.g., Haelermans et al. 2015; Keane and Heinz 2019; Magebleh and Abdullah 2020; Morgan 2013). eLearning technology can afford the customization of learning to suit individual student's needs (Groff 2013). Specifically, teachers can make use of eLearning technology to proactively differentiate learning content, teaching methods, resources, and outcomes based on students' needs. Such techniques can maximize the learning opportunities for every student, which in turn enhances students' intrinsic motivation, productivity, and achievement (e.g., Amabile 1996; Collins and Amabile 1999; Tomlinson et al. 2008).

Differentiated learning is particularly important in classrooms that are typified by academic diversity in terms of students' readiness, interest, ability, and learning profile, such as giftedness, special educational needs, and cultural diversity (Tomlinson 2003; Handa 2019). eLearning technology can facilitate the in-class arrangement of learning activities that are tailored to address these unique learning needs.

In one of our observations, different learning activities were arranged for two groups of junior secondary school students in a mathematics class based on their ability (Case G). Advanced students in the class were asked to search for the price of different items online, calculate the total cost, and make a PowerPoint presentation to the whole class. The remaining students practiced calculations through hands-on activities with concrete objects of cookies and playing cards. We also observed this practice in a Chinese

reading and comprehension class for Key Stage 3 students in a special education classroom (Case H). In this class, students were grouped according to their differential learning stages. That is, those who showed advanced reading and comprehension skills were asked to analyze the content of a passage in an interactive online game, while the remaining group was asked to answer knowledge questions in an eBook. Analyzing the content was more suitable for the advanced students because it involved more complex thinking skills than respond to knowledge questions (Anderson and Krathwohl 2001).

Apart from working on a group basis, this teacher selected some students to complete extra learning activities based on their abilities and interest. One student was chosen to control and manage the computer during class because he was good at using electronic devices. Another student was selected to record and upload his speech because he had accurate pronunciation. His speech could help other students to learn outside the classroom. In these examples, teachers demonstrated how different learning activities can be tailored according to students' learning needs. Incorporating eLearning technology holds promise to widen the options for learning activities, which in turn provides a wide range of possibilities for differentiated learning.

3 Discussion and conclusion

To explore the potential of how eLearning can facilitate a paradigm shift in education, this paper discussed and illustrated some of the opportunities for eLearning to improve classroom teaching and learning practices. Specifically, eLearning technology has been found to transform traditional teaching practices into constructivist practices. Teaching and learning practices were observed across multiple classrooms to illustrate the current status of eLearning and to showcase how eLearning technology can bring different constructivist pedagogies into practice.

In our experience, eLearning technology can enrich teaching and learning practices in real-life settings. These enriched teaching and learning experiences would be less accessible without eLearning technology (Groff 2013). Specifically, the current research observed that eLearning technology could enable students to become autonomous learners that actively explore the learning content (i.e., active learning), to decide their own learning goals and pathways (i.e., student-centered learning), and to fulfill their unique learning needs (i.e., personalized learning). It also provides opportunities for students to learn together in a co-operative and competitive manner (i.e., peer learning). Moreover, it facilitates teachers to offer differentiated teaching instructions to suit students' unique learning needs (i.e., differentiated learning). These findings indicated that eLearning can be effectively adopted to bring at least five different pedagogies into practice, thus promoting a constructivist learning environment for students. These findings can extend the existing literature on eLearning. There is abundant research attention on its benefits, such as learning satisfaction and outcomes (Eom 2014).

Apart from eLearning, the present research can in fact promote the constructivist movement practically. Windschitl (2002) identified four important dilemmas for teachers adopting constructivist teaching, which include conceptual, pedagogical, cultural, and political considerations. The representative examples identified in this research can provide solutions to address the pedagogical dilemmas concerning how

teachers design the curriculum and learning experience to fulfill the requirements of constructivism. Therefore, teachers can devise their constructivist teaching strategies with reference to the representative examples illustrated above. These representative examples can be adopted as resources to develop guidance for teaching and inspiration for workshops sharing how to implement eLearning technological tools.

Beyond pedagogical philosophies and constructivist movement, the current research provided evidence to show how eLearning can benefit the learning process in general. There are research syntheses showing that incorporating technological tools is beneficial to students' learning. For example, among 24 studies, incorporating technological tools in learning mathematics had a moderate to strong benefit on student's learning performance, learning motivation, and learning attitude (e.g., Higgins et al. 2019). The present findings not only supported the benefits of incorporating eLearning technology in learning but also showed how technological tools could be incorporated in real-life settings and, more importantly, across different age groups and academic disciplines. To be specific, this research investigated the implementation of eLearning across primary, secondary, and special education schools in Hong Kong. We observed that learning activities utilizing eLearning tools could be varied to suit the needs of students in different years of study.

Our findings also shed light on the functions of incorporating technological tools in enriching teaching and learning practice. It is understandable that the class capacity has a direct influence on teaching and learning performance. Specifically, the increase of class capacity is usually related to the decrease of in-class interaction between teachers and students as well as shorten students' attention span on learning (Wood and Shirazi 2020). Our findings clearly illustrated that technological tools could be a solution to enrich teaching and learning practice. First, technological tools, such as student response systems, can facilitate the delivery of learning materials. The learning materials can be delivered in a variety of ways that are useful to engage students. In one of our examples, students can explore the properties of different three-dimensional shapes on their own. This is in line with the existing studies showing that technological tools can provide a well-designed environment with adequate guidance for students to learn (Gibson 2018). Second, technological tools can also be a communication medium for teachers and students. Students can express their own understandings and ideas while teachers can collect instant feedback from the class to monitor the learning progress. In our examples, students were motivated to express their ideas while teachers gained better control over the teaching process, which enriched the learning atmosphere and facilitates in-class communication. Thus, the flexible use of such tools can bring practical benefits to the teaching and learning process. Therefore, it is a golden opportunity for teachers to consider how to make use of the rapid technological advancement to improve their teaching practices, as well as for students to consider how to maximize their learning gain in a technology-enriched learning environment.

There is a caveat that awaits future research attention. This research investigated only the education system in Hong Kong. Such a context-specific research design may indicate that the findings may not be generalizable to other parts of the world. Therefore, future research is needed to conduct a similar investigation in other cultural contexts. However, the findings offer valuable insight to showcase that eLearning technology can benefit the learning process by bringing different constructivist pedagogical philosophies into practice. We hope this paper will stimulate further discussion

on how eLearning technology can best be applied to educational settings so the learning process and outcomes can both be optimized.

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Compliance with ethical standards

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Affiliations

Paul L.C. LAM[1] · Hilary K.Y. NG[1] · Alan H.H. TSE[1] · Ming Lu[2] · Bernardo Y. W. WONG[1]

[1] Centre for Learning Enhancement And Research, The Chinese University of Hong Kong, Sha Tin, Hong Kong

[2] University of Cologne, Germany, Cologne, Germany